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COVER—A crippled spacecraft prepares for a fiery reentry in *Apollo 13*.

QUICK CUTS

THE GHOST AND MR. MUREN

article by Jody Duncan

Fifty years after Paramount Pictures introduced the sweet-natured, but lonely *Casper* in a cartoon short, Universal Pictures and Amblin Entertainment have collaborated with executive producer Steven Spielberg, director Brad Silberling and producer Colin Wilson to bring the beloved character to the big screen in *Casper*. As evidenced by the hit summer release, time has been nothing but kind to the friendly ghost. Thanks to the wizardry of digital character supervisor Dennis Muren, animation director Eric Armstrong and Industrial Light & Magic's team of computer graphics artists, *Casper* has been transformed from the simplistic, two-dimensional character of Harvey Comics fame to a fully realized, three-dimensional actor.

With 360 computer generated shots – as compared to *Jurassic Park*'s fifty-five – and a full forty-seven minutes of screen time devoted to digital characters, *Casper* represented a throwing down of the gauntlet for ILM's celebrated CG department. More significant than the size and scope of the assignment, however, was the subtlety and sophistication of the computer animation mandated by the storyline. "At the beginning of the show," said Dennis Muren, "we all thought that we would be doing a version of the cartoon *Casper* who had only three feelings – happy, happier and happiest. Even in our initial storyboards, he was always smiling. But the more we got into it, the more we realized that *Casper* was as complicated a performer and thinker as a person, and his emotions were as human as any other character's."

The screenplay by Sherri Stoner and Deanna Oliver has *Casper* and his odious uncles – Stinkie, Stretch and Fatso – haunting an abandoned mansion, Whipstaff Manor. Greedy Carrigan Crittenden (Cathy Moriarty) inherits the manor; and upon learning that there is treasure hidden within, she and her hapless partner Dibs (Eric Idle) resolve to rid the house of the pesky ghosts. When attempts by amateur exorcist Father Guido Sarducci (Don Novello) and even a celebrated ghostbuster (Dan Aykroyd) fail to do the job, Carrigan turns to spirit shrink Dr. James Harvey (Bill Pullman). Harvey and his daughter Kat (Christina Ricci), move into the manor; and eventually a friendship blossoms between *Casper* and the lonely young girl.

ILM became involved in the show with a preliminary test in June 1993. "Contrary to popular belief," Muren commented, "ILM does not get every Spielberg project. We had to compete, just like everybody else. So we did this test in which *Casper* comes into a bedroom, looks in a mirror, winks at the camera, and then flies into the mirror and disappears. Another company did a test as well, but Steven preferred ours. So we got the job; and suddenly we were faced with this huge show."



In *Casper* – an Amblin production with effects by Industrial Light & Magic – a lonely ghost falls in love with

a young girl whose father is hired to rid an old mansion of its resident spirits.

Digital effects producer Janet Healy and digital character co-supervisor Stefen Fangmeier were responsible for assembling the ILM crew. A number of new animators were hired, and the technical problems involved in producing such a large number of shots were addressed. "We had to advance our production techniques because we had to put so many shots through," Muren said. "We also had to rewrite and upgrade a lot of our internal software so that it was more easily employed by a greater number of people. When we started, there were only six people working on *Casper* who had worked on a movie before. We hired more than sixty people for this show. Many of them came from a commercial or industrial background, and some were straight out of college. So we had to make our software easier to use."

Once awarded the job, ILM concentrated its early efforts on what *Casper* and the other ghost characters should look like. "There were questions as to whether *Casper* should look externally lit or internally lit, and eventually everyone seemed to respond to the former. There were also questions as to how much transparency there should be, how much glow around the edges. In CG, there was a lot we could do with the softness of the edges and the refraction. Everything was controllable; and we did whatever we could to make *Casper* look magical."

One of the difficulties ILM faced in the design phase was that the two-dimensional character did not readily translate to three dimensions. "We found that there was no way to communicate from the 2-D world to the 3-D world," Muren related. "In 2-D, you cheat things all the time to make things look good – you cheat natural laws of physics. But you can't cheat those things in 3-D. You can't slide the features around on the face to make it look good for one particular shot, from one particular camera angle. So all the 2-D concepts were useful as tools in visualizing the character attitudes, but they could not be taken literally." To extend the design effort into the 3-D world, ILM and The Character Shop produced concept sculptures and maquettes for each of the CG characters.

Early in the development process, ILM experimented with the idea of *Casper* being made up of a floating, transparent vapor. Despite the investment of considerable time and energy, however, that approach did not prove successful. "CG never does natural phenomenon such as vapors or smoke very well," Muren stated. "Another problem we had with that look was that it made it difficult to read the character's expressions. There was white vapor for his body and then blue vapor for his eyes and dark



To produce the ghostly images – some forty-seven minutes of screen time – ILM composited three-dimensional computer generated characters into live-action plates.



vapor for his eyebrows – it got very complicated. In theory, it was a good idea; but if audiences couldn't read the performance, the movie wasn't going to work. So from there we fell back and decided to make him look harder-edged." Eventually, through much trial and error, the CG team came up with a design for *Casper* that was human-like. "Casper was human at one time, so that human quality was there. He had hands and joints, with a little flipper tail. He followed certain laws of physics."

To produce the ghostly images – some forty-seven minutes of screen time – ILM composited three-dimensional computer generated characters into live-action plates.

Designs for the other spectral characters were being developed at Amblin, including the ghosts of Carrigan and Dr. Harvey that are featured near the end of the film. "We wound up making those ghosts look much more real than *Casper* and his uncles," Muren commented. "There were sculptures of the Carrigan ghost and the Harvey ghost that had been approved; but when we got those concepts on the screen, they were too ghost-like and they looked silly. These characters had been seen as live people throughout the rest of the show, and it was difficult to suddenly accept them as caricatures. So we began pushing the Carrigan and Harvey ghosts into a look that was more real."

ILM continued to refine the appearance of the characters even as principal photography began in January 1994, with visual effects plate supervisor Scott Farrar overseeing filming of the background plates. During the shoot, Silberling determined to make the ghosts as much a reality for the cast and crew as possible. Rather than prerecording actors Malachi Pearson, Joe Nipote, Joe Alaskey and Brad Garrett – the voices for *Casper*, Stretch, Stinkie and Fatso, respectively – and relying on the playback of that recording, Silberling had the voice actors on the set throughout the shoot to interact with the live-action characters. Another technique used to ground the characters in reality was to have animation director Phil Nibbelink do rough, on-the-spot animatics on the set. "Phil set up an Amiga system that enabled him to grab a video-tap image and overlay that image with a real quick cartoon animatic," Muren said. "Then Ian Kelly, the video engineer, would edit it together. The cartoons were very crude, but they showed how *Casper* and the other ghosts related to the live-action characters and how big they were in the frame. There was no intent to show a performance; they were just a reference to show the cast and crew where the CG characters would be in the scene."

Once principal photography was completed, Silberling – who had very specific ideas regarding the performances of the digital characters – was faced with the prospect of turning over the creation of those performances to ILM. "Brad couldn't really walk away from the film at that point," commented Muren. "He had to stay with it, because he knew the rhythm of the scenes and the attitudes of the characters. So he came around to accepting that he was going to be on the show for another nine months; and instead of directing a few actors, he was going to have to direct twenty-five animators. It was the only way to get his vision across."



Casper's troublesome uncles encounter a vacuum cleaner in a scene demonstrating close interaction between live and digital performers.

Early on, Muren had suggested a rather radical idea to help bridge the gap between Silberling's vision and the final performances. "My original thought was that Brad could direct actors portraying *Casper* and the other ghosts on the sets after he was done with principal photography. He could rehearse them and get just the performances he wanted, shooting video. Then he could give that video to us, and we could use it as a guide. If we'd had an actor's performance early on, it would have been clear what the concept was; and then that could have been interpreted to the ghost shape. But, of course, there's never money for that kind of thing. I don't know of any studio that would include that in the budget, because it's not 'real' footage." The next best option was to have Phil Nibbelink and a team of three animators flesh out the original animatics that had been generated on the set. The animators spent months refining two-dimensional animatics that, unlike the originals, contained more specific performances. "By the time those animatics were done, anybody looking at them could tell what the character's attitude was and what he was feeling."

With animation director Eric Armstrong taking the reins, *Casper* segued into postproduction. Computer models for all the ghost characters were built, with particular attention paid to the facial areas. "We had to get both large movements and very small movements out of those faces," stated Armstrong, "which meant we needed a broad range of control. We also had to pay a lot of attention to the bodies. We spent a lot of time rebuilding and fixing joints and other areas so that we could get optimum movement without getting folds and things like that. Because they were ghosts, these characters were very smooth-skinned – unlike the bumpy dinosaurs in *Jurassic Park*. Every little flaw and wrinkle jumped right out on these smooth transparent surfaces, so our enveloping needed to become much more sophisticated."

Because of their part-corporeal, part-spectral nature, modeling the Carrigan and Harvey ghosts was particularly painstaking. "Dave Carson, our character design supervisor, spent a lot of time on those models," Armstrong said. "Bill Pullman and Cathy Moriarty have very specific nuances about them: Bill has a funny way of smiling and his mouth doesn't open very wide when he talks, whereas Cathy is very broad in everything she does. We looked at those nuances and tried to match them in the modeling and animation so that those characters would read and be consistent. That was a big challenge because we were going from a live performer that the audience has seen all the way through the movie to a CG-version ghost that had to be just as good and just as entertaining."

Once the models were sufficiently refined, the *Casper* team moved on to the animation phase of the project. Although he had years of experience in both traditional and computer animation, Armstrong soon realized that *Casper*'s animation would require a whole new level of sophistication. "We went into *Casper* with what we had learned on *Jurassic Park*," Armstrong commented, "but we discovered that the animation techniques we had established with *Jurassic* were not going to do the job. A dinosaur's emotion is defined by 'does he eat other dinosaurs or do other dinosaurs eat him?' That was the extent of the expression and emotion required. But with *Casper* we took this giant leap. We went from doing creatures that emoted a small amount to these characters who were supposed to be dead human beings and who had every kind of emotion. We also had to be extremely subtle in the performances. Traditional cartoons have big, broad, exaggerated actions; and that's easy to do. But when an animated character has to share a soft, gentle moment with an actor, that requires extraordinary subtlety. Subconsciously, we know what a human being looks like when he is sad – it's a combination of a lot of little signs and behaviors. Suddenly, we had to

recreate all those little signs and behaviors with these digital characters, which was very difficult. To do it, we developed tools that would allow the animators to concentrate as much as possible on the artistic and performance side of the job, rather than on the technical side.”

Among those tools was a library of facial expressions that the animators could employ as needed. “It was similar to what’s been done with stop-motion work in the past,” Armstrong related, “where animators build hundreds of heads with different expressions, and then replace one head with another. Instead of replacing heads, we were actually creating key frames – it’s always the same head, but its shape changes from frame to frame. This library at least got us in the ballpark each time we needed a specific expression, even though we still had to go in and refine it significantly for each shot. We would plug all these faces in, and then we would deal with how the face changed from one expression to another, how it made that transition.” The library also was instrumental in maintaining consistency from shot to shot. “Something every traditional animation studio faces is keeping a character ‘on model.’ Every artist draws differently, so you are always having to make sure that the character isn’t deviating too much from artist to artist. By building this library of faces, we knew the character was always on model because every animator was starting with the same sets of faces each time.”



Digital character supervisor Dennis Muren and animation director Eric Armstrong study a scene.

Another animation tool used on *Casper* was motion capture technology. One of the crew members had sensors attached to her mouth as she lip-synced to the prerecorded lines of dialogue, with the raw motion data then being translated to a moving mouth image on the computer screen. The hope was that motion capture would ease the burden of lip-syncing nearly forty minutes’ worth of dialogue by hand. “These characters were talking all the time,” Muren said, “and it would have been extremely time consuming to lip-sync all of that dialogue from scratch. Lincoln Hu set up the motion capture for us, and we used it for the first pass on the mouth movements. Then the animators would go in and embellish it. Some of them didn’t like using the motion capture stuff at all; they preferred to do all the lip-syncing by hand.” The option of also using motion capture for the facial and body animation was explored early on, but was dropped when the resulting animation proved less interesting and dynamic than that rendered by the animators themselves.

Animation for any one shot would take from two weeks to two months to complete. Unusually long shots and complex camera moves made the animation a particularly labor-intensive endeavor. “Scott Farrar and I had discussed early on how much we wanted the CG to influence Brad in how he shot the movie,” Muren noted. “My feeling was that we shouldn’t influence him at all, that we should let him do whatever he wanted. I think you can tell when an effects person has been in there affecting the flow of a movie. So there were shots that were way over a minute long, with the camera slowing dolly in on two characters. In the final result, the film flows much better because it’s all done in the director’s style.”

In the compositing stage, the animated models finally took on their ethereal characteristics. “We created the glow and shadows at varying densities,” said Muren. “There were all sorts of aesthetic calls that we had to make throughout the process for every shot. It was great because there is so much flexibility in CG.” The Carrigan and Harvey ghosts, which looked more like their human counterparts, required more detailed rendering. “Cathy Moriarty had makeup on in the live-action,” Eric Armstrong commented, “so we had to paint makeup on her computer model as well. Likewise, we had to paint in the beard stubble that Bill Pullman had. The TDs also spent a lot of time on lighting to make them look good, just as you would do with any star.”

Casper opened big on Memorial Day weekend and continued to top the boxoffice charts in the weeks to come, much to the delight of Muren, Armstrong and all of the ILM team members who had labored for a year or more on the film. Muren, in particular, came out of the project with a new awareness and appreciation for the animation art form. “I had always admired animation, but I was not particularly sensitive to what it entailed. Now, I look at the Disney animated movies, like *Beauty and the Beast* or *The Lion King*, and I am amazed at what it takes to do that kind of animation. I see it much more clearly now. Those films, animation-wise, are perfect. Our goal on *Casper* was to at least attempt to reach that same level of animation, but in the 3-D world.”

SPECIAL VENUES

MGM'S GRAND EFX

article by Jody Duncan

In Las Vegas, a town known for extravagant entertainment, the MGM Grand Hotel's EFX is the biggest, most extravagant show of all. Part magic show, part musical, part special effects spectacle, the \$40 million multimedia production pulled in not only Michael Crawford – whose household-name status was ensured with his long run as the Phantom in Andrew Lloyd Webber's *Phantom of the Opera* – but also some of the legitimate theater's best and brightest directors, choreographers, designers and musical directors. As the ninety-minute show unfolds on a huge stage, set pieces are flown in and out and up, animatronic dragons rise from the stage floor, and Crawford himself appears and disappears with all the panache of Siegfried and Roy's white tiger.

The virtually plotless show, which opened in June, stars Crawford as the Master of EFX, a sequin-studded emcee who serves as a tour guide through a series of vignettes, including Merlin and Arthur's battle with the evil Morgana, a comedic circus display and H.G. Wells' surrealistic journey in his time travel machine. This last sequence features a two-and-a-half-minute 3-D film – projected on a giant, eighty-foot-wide screen – directed by Bruce Schluter and realized by Rhythm & Hues. In the segment, Crawford climbs aboard his time machine and instructs audience members to put on their protective goggles – actually a pair of polarized, 3-D glasses inserted into each program. As the time machine rises toward the rafters, the screen lowers and the filmed time travel adventure begins.

Rhythm & Hues began their EFX stint in April 1994, with head technical director Georgia Cano, art director Lorne Lanning, producer Ellen Coss and executive producer Sherry McKenna collaborating with director Schluter to visualize the film. "The director knew very specifically what he wanted in the film," noted Cano. "We had input into the look of the images, but it had already been determined what those images would be." As conceived, the film would feature the time machine traveling through a range of environments in what would appear to be one long, continuous take. With the exception of live-action elements of a Beethoven-like character at a piano, a knight in armor and a life preserver splashing into a body of water, all of the elements would be computer generated.

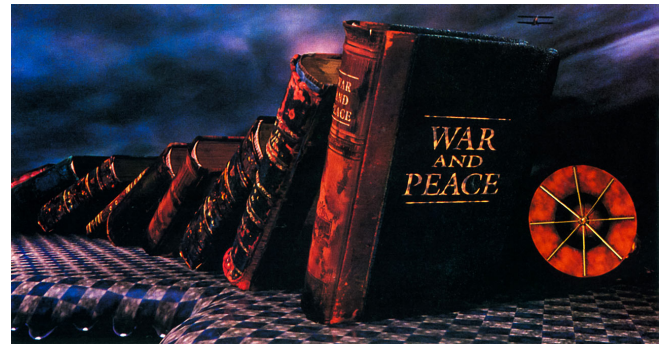
The movie begins with light streaks forming faces of historical figures such as George Washington and Abraham Lincoln. The light streaks then dissolve to a 'universe of clocks.' The first 3-D effect is experienced when one of the twenty or so computer generated clocks appears to fall forward from the screen. "After the clocks, we pull back as the time machine moves up through a window and into a cathedral," Cano said, "and that is where we see the live-action pianist flying by. The pianist was shot by The Chandler Group, and then we composited that with CG shots of musical notes coming out towards the audience."

The camera continues to pull back, revealing a row of books which fall in a domino effect. From there the film transitions to a segment featuring vintage airplanes which appear to fly out over the

audience. A bright blue sky turns increasingly dark and ominous as the shot continues, providing a segue to images of a kite flying in a lightning storm with its tail floating out in 3-D space.

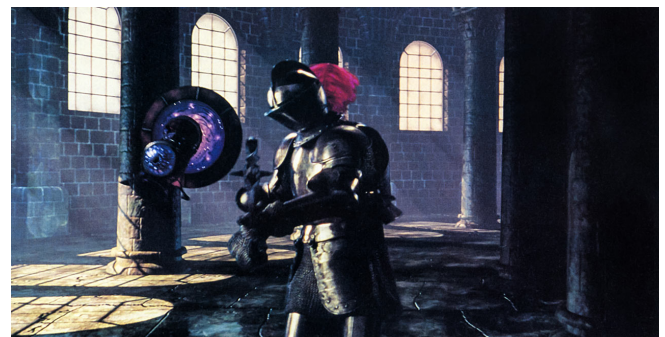
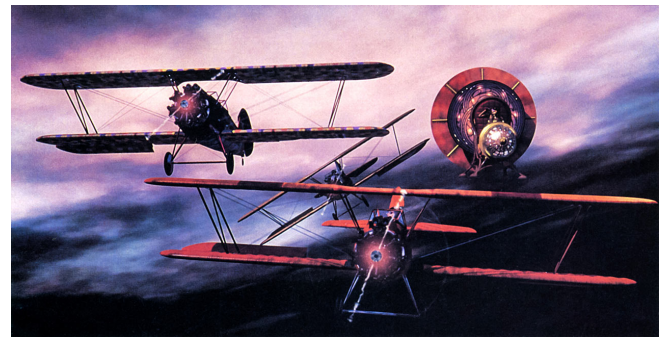
The live-action element of the life preserver splashing down leads to the next sequence showing colorful fish swimming underwater. One of the fish morphs into a lizard-like creature which then grows to fill the frame, opening its mouth and becoming a time-travel tunnel. The tunnel was made up of clock faces and a swirling cloud background, and the 3-D effect was realized with arrow-shaped hands which seem to point toward the audience. With a pass by Dorothy's floating house from *The Wizard of Oz* and an MGM gold coin, the tunnel becomes a starfield which then goes to darkness as the film ends.

The time machine itself was not modeled and animated until the entire fly-through had been completed. "We put the time machine in last to follow the camera's path," said Cano. "We did both a CG time machine and a CG Michael Crawford sitting inside. For that we did motion capture on one of our TDs. We made a little model and then animated it using the motion capture data. There was a fair amount of movement because Michael Crawford is supposed to be reacting to everything as he moves through these environments – he ducks when the books fall for example, and he waves to a pilot in one of the planes. We animated all of that and timed it to the actions of the other objects in the film."



For the EFX extravaganza at the MGM Grand Hotel in Las Vegas, Rhythm & Hues produced a computer generated 3-D journey through time.

EFX marked Rhythm & Hues' first experience with 3-D, and required a crash course in the technique. Live-action 3-D is generally achieved by shooting with two cameras set up side-by-side with lenses spaced in correlation to the distance between a viewer's left eye and right eye. The result is separate footage as it would be seen from the perspective of the left eye and from the perspective of the right eye. When the imagery is overlapped and viewed through polarized 3-D glass, those two perspectives appear to converge, and an optical illusion of three-dimensionality is created.



In the computer, the effect is realized during the rendering process. "We instruct the computer to make one camera render at this perspective and the other camera render at that perspective," Ellen Coss explained. "There is a slight difference in the perspectives of those two cameras – the same as you see when you cover one eye and look at an object, then cover the other eye. The distance between your two eyes is called the interocular; and

in the computer we can change the interocular setting to get the best 3-D effect. So we are rendering one camera, then rendering the other, offset by a couple of inches. The other aspect to creating 3-D is the convergence – the distance the object has to be at in order for your eyes to converge and see it from one perspective. We tell the computer camera where we want that point to be – everything is mathematical – and if the 3-D effect isn't clear enough, we change the convergence until we like the effect we're getting."

While mastering the technical requirements of 3-D, Rhythm & Hues also discovered choreographic tricks that would show off the effect to its best advantage. "What worked best was to have an object come out and sit in space for a while so audience members would have a chance for their eyes to adjust," Coss said. "Another thing we learned was that as soon as an object broke the frame line – that is, exited the screen left or right – the illusion of 3-D was completely destroyed. We've all seen enough movies to know that if something can exit the screen, that means it is on the screen plane, and thus it is a 2-D thing. So we came up with ways to avoid that. For instance, the musical notes that come out of the piano become blobby and disintegrate – that was a way to get them off the screen without having them exit right or left."

To evaluate their work in progress, the digital artists used the CrystalEyes system which enabled them to view the 3-D effect in video tests. "The system takes 30 frame-per-second video and splits it up into sixty fields per second, alternating one field for one eye and the other field for the other eye," Cano explained. "That syncs up with your computer monitor – which is showing you the left eye and right eye simultaneously – and lets you see the 3-D environment. It was very helpful."

As Rhythm & Hues completed its EFX assignment in November, other 3-D projects were already on the horizon. "We've had a very positive response to our work on this project," Coss observed, "and I foresee a lot of future 3-D projects coming out of it. Because it is so much more workable in CG than it is in live-action, I think there is a huge trend coming in computer animated 3-D."

QUICK CUTS

COWBOYS AND INDIANS

article by Jody Duncan

The Kennedy/Marshall Company's production of *The Indian in the Cupboard* is based on Lynne Reid Banks' award-winning novel about a young boy named Omri (Hal Scardino) who receives a magical antique cupboard for his birthday. Placing a three-inch-tall toy Indian inside the cupboard, the boy goes to bed, only to be awakened in the morning by the sound of faint scratching. Opening up the cupboard, he finds a living three-inch-tall Iroquois Indian from the 1700s named Little Bear. Omri soon learns that with each locking and unlocking of the cupboard, toys placed inside are transformed into living counterparts, then back again. Directed by Frank Oz and written by Melissa Mathison – who scripted *E.T.* – *The Indian in the Cupboard* is not so much about the cupboard's magical properties as it is about the relationship that forms between the boy, the Indian and a similarly diminutive cowboy named Boone.

Industrial Light & Magic's Eric Brevig served as both visual effects supervisor and second unit director on the production. A veteran of *The Abyss* and *Total Recall* – for which he won an Oscar – Brevig had also been involved with the effects work on *Hook* and several 3-D theme park films, including *Honey, I Shrunk the Audience*, for which he served as a consultant. Thus experienced in dealing with contrasting scales, Brevig was well prepared for his *Indian in the Cupboard* assignment which consisted of about 140 digitally composited effects shots.

"What the visual effects did for this movie was allow characters that were three inches tall to interact with the boy," Brevig related. "There is an entire relationship between the boy and these small people, and most of it takes place in the world of the boy's room. What we were doing was facilitating the audience to take for granted that these people were three inches tall. In order to allow them to interact in a normal-sized environment, we had to do the most meticulous effects work that has ever been done in this type of movie. We built into the shots all the tell-tale artifacts – such as shallow depth of focus – that we would have gotten if we had actually photographed tiny characters."

Both live-action and bluescreen units were set up on soundstages at Sony Studios. "Frank was directing live-action on one stage and I was directing the bluescreen second unit on another," Brevig explained. "Half of our stage was taken up with a 150-foot-long by 35-foot-tall bluescreen.

At the other end of that stage we had a replica of the bedroom set that was the main background for most of the shots. We employed that set anytime a meticulous camera setup was necessary. We preferred doing that on our second unit set, rather than doing it in the middle of first unit with the



In *The Indian in the Cupboard*, sophisticated digital compositing was employed by Industrial Light & Magic to

actors cooling their heels. It made sense to juggle the work.” To accommodate the child actor’s short work day, the production came up with a shooting schedule in which the first unit work was filmed in the mornings, followed by second unit in the afternoons to evenings. “The adult actors playing the small characters would be there for first unit in the mornings, to speak their dialogue off-camera, then come to the second unit stage for the rest of the day.”

depict the story of a young boy whose toys come to life when placed in a magical antique cupboard.

Originally, the game plan was to achieve many of the shots with oversized sets, the technique employed for *Honey, I Shrunk the Kids*. That approach was dropped in favor of composites, however, when the switch to large-scale sets appeared too obvious in initial photography. “We wound up not relying on oversize sets and those kinds of tricks to a great extent,” Brevig noted. “In general, the backgrounds would be filmed first with the boy actor playing to some kind of doll or other guide on the set. The actors – either Litefoot as the Indian or David Keith as the Cowboy – would be off-camera speaking their dialogue. Then, on the bluescreen stage, we would shoot Litefoot and Keith, duplicating all the camera moves, camera positions and lighting.” Bluescreen director of photography Chuck Schuman took extensive notes as the backgrounds were being filmed to ensure that camera information and lighting would be duplicated precisely on the bluescreen stage. “Chuck would take all the light readings, the color temperature of every light source – things like that. He was very meticulous about it.”

On the bluescreen stage, both camera moves and lighting had to be scaled up. “Because the actors were actually twenty-four times larger than they were supposed to be in the movie, all of the lighting information had to be scaled up twenty-four times to match the appropriate relationships. That was no small undertaking. A 10K light on the live-action set would have to be simulated on the bluescreen stage with a source that was twenty-four times bigger to match the quality of the light.” Camera moves were also scaled up to accommodate the actors’ actual size. “For instance, if the camera dollyed two feet on the live-action set, we would do a camera dolly move that was twenty-four times bigger; so that two-foot dolly would translate to a forty-eight foot dolly move on the bluescreen stage. We had to do a lot of work on giant crane arms using Wescam gyroscopically stabilized devices that enabled us to haul a Vistavision camera through eighty feet of space in three seconds, or whatever the shot required. That was the most difficult part of this – the scaled-up camera move had to be done in the same amount of time as the small move on the set. We were fighting all the laws of physics, trying to move heavy cameras through space without all the shaking you get with typical physical effects rigs. These Wescam rigs were essentially helicopter mounts hung up on cranes. We used big Titan



With careful attention to lighting and camera moves, actors portraying the tiny toy characters were photographed on a bluescreen stage and match-moved into full-size background plates.

cranes or Matthew arms, which are very long, specialized arms. A small number of guys could swing those arms and accomplish a great deal of camera motion.”

The resulting bluescreen photography was match-moved in postproduction, frame by frame, to the live-action backgrounds which were usually shot wild, without motion control. “In some cases, however,” Brevig said, “if the little character was leading the action, we would shoot the bluescreen footage first, as if the cameraman was following him. Then we would track exactly what the camera had done and photograph the backgrounds using motion control.”

The illusion that the tiny characters and the boy had been filmed in the same environment was enhanced during compositing. “We were able to finesse things a lot in the compositing stage. We took people who were shot against bluescreen and put them in the environment with reflections, shadows, color casts and other artifacts. Because it was digital, we were able to keep improving on it using 3-D computer graphics tools.”

One of the most complex and satisfying scenes in the film has Omri gathering up all of his favorite toys and putting them in the cupboard once he discovers its transformational capabilities. “We have a shot of Darth Vader battling the T-rex from *Jurassic Park* inside the cupboard,” said Brevig. “And on the bottom shelf, RoboCop is fighting with some of the *Star Trek* aliens. Steven Spielberg gave us approval to use the real T-rex from *Jurassic*. We took the T-rex computer model, the actual data base, and modified it somewhat so it would look like a toy. All the other characters were played by actors in costumes, shot bluescreen. It’s a wonderful scene, and it was great fun to do. Audiences loved it so much in test screenings that we added another shot to extend the sequence a bit.”

Although Frank Oz built his reputation with effects projects such as *The Dark Crystal* and *Little Shop of Horrors*, the director endeavored to make *The Indian in the Cupboard* a film in which the relationships were paramount and the effects incidental. “When we were done with the film,” Brevig recalled, “Frank pointed out that it was amazing to see how moving and strong the relationship was between the boy and the Indian. He marveled that we had accomplished that with two performers who were never in the same room together. The whole movie is about the two of them interacting, but there was no interaction. The reality was that Frank shot the boy on one stage and I shot the Indian on another.”

COMMERCIAL SPOT BEAR NECESSITIES

article by Estelle Shay

We've seen them swigging Coca-Cola. Now they're plugging cars. In Honda's latest pitch for its sporty new Passport, bears are once again charming viewers with their antics. When three of them spy the vehicle parked along a wooded road, they amble over with ursine inquisitiveness, then proceed to peer under the hood, kick the tires, open the hatchback, climb inside and do everything but take it for a test drive.

To bring their clever premise to life, ad agency Rubin Postaer & Associates, production company Sandbank, Kamen & Partners and director Henry Sandbank turned to the Los Angeles division of Jim Henson's Creature Shop, noted for its particular expertise in building animatronic animals. "They wanted life-size, realistic-looking bears," observed creative supervisor Dave Barrington Holt, "so that viewers would wonder, 'Is this real or isn't it?' Since using trained animals wasn't feasible, we suggested building a realistic bear suit and enlisting an actor skilled in animal performance." With insufficient time or budget for three suits, the Creature Shop was commissioned to build just one. "The idea was to make it neutral-looking enough so that we could use it to represent all three bears, then composite the shots to sell the concept of there being more than one."

With just seven weeks in which to prepare for the shoot, the Creature Shop began a frantic search for a suitable performer. "The performer is crucial to the effect," observed Barrington Holt, "because the costume is created around him. For starters, we needed someone who had the right physical attributes for a bear – namely a long space between the shoulder and the hip." As the search got underway, the effects team learned that animal performer and stuntman Dave Forman was in town. "That was tremendous good fortune because Dave has worked with us for a decade or more, and is a real bear specialist with a lot of knowledge and experience in playing bears." Although Forman accepted the assignment, he was on his way to China to work on Little Panda, and had just one day to spend with the effects team. "We didn't have to worry about training him, but when you're building a costume like this, you really need to have your performer there. Fortunately, we already had a body cast, and were later able to glean measurements from an old walk-around polar bear suit we had made for him previously."

Work began with construction of a semi-rigid skeletal understructure built by lead costumer Niki Lyons. Made from assorted plastics, rubbers and nylon sheets, it was strong enough to maintain its shape, yet flexible enough to allow the performer comfortable movement inside it. "What you try to do," related Barrington Holt, "is visually spread the shoulder and the hip to make the legs of the actor look shorter than they really are, and to make his back look longer." To further disguise the performer,



a muscle suit was fabricated to provide bulk in appropriate places as the skeleton moved. "Part of the muscle structure was affixed to a one-piece lycra jumpsuit worn by the actor, while other parts were hooked onto the skeletal structure. The skeletal shoulder blades and forelegs and their associated muscle groups were detachable so that Forman could wear the body and back legs of the suit, but have his own arms free whenever he wasn't performing."

A curious bear examines a Honda Passport in a commercial employing an animatronic bear suit built by Jim Henson's Creature Shop.

While sculptor Peter Brooke created the brown bear head, mechanic Mike Scanlan began work on the underskull – a sixteen-servo mechanical construct with facial articulation that encompassed eye, eyebrows, snout, lips, jaw and tongue movements. Those were operated by a puppeteer using a portable version of the company's award-winning computer-based control system. "From our point of view, the head was a relatively straightforward job," remarked Barrington Holt. "The character didn't have to speak or even particularly emote. The only emotion the director was after was curiosity, and that could be achieved with simple moves."



Lead costumer Niki Lyons uses a shaver to shape and trim fur on the nearly completed bear suit.

Particular care was taken to build the head as lightweight as possible. “We eliminated metal parts whenever we could, and employed very advanced substances – mostly kevlar carbon fiber, a strong, rigid, lightweight aerospace material.” Minus fur and skin, the completed head weighed only two and a half pounds. “It was the lightest bear head we’ve ever built,” said Barrington Holt, “which was important because the weight of it – cantilevered forward from the performer’s head – puts a lot of stress on his neck.” A supporting neck mechanism helped reduce the stress and facilitate head movement. “We built a fiberglass skull cap that clamped onto the performer’s head and connected to a mechanical linkage that allowed him to turn the bear head from side to side, plus raise and lower it.” Electronics for the facial articulation – designed by Jeff Forbes – and a receiver-transmitter for communicating with the puppeteer were strapped in a battery pack to the performer’s waist, while a small scrim in the neck provided a window to the outside world.



On location for the shoot, Henson crew members suit up performer Dave Forman.

A fur suit was created by Lyons and costumers Jill Thraves and Julie Zobel using National Hair Technologies’ two-way stretch fur fabric. For the head, mold shop supervisor Phil Jackson fashioned a pair of foam latex skins which were sent to the London Creature Shop for the delicate job of hair replacement. There, technicians Vin Burnham, Tacy Kneale and Ali Eynon applied the head fur using a combination of dyed goat hair, yak hair and fake fur. “By the time we got it back, Dave had returned from China,” said Barrington Holt, “and with him inside the suit, we were able to sculpt and shave the hair to further accentuate muscle groups and get the variations in length required for different parts of the body.”

In creating the front paws, Barrington Holt – upon Forman’s urging – agreed to forego the leg extensions ordinarily used to adjust for differences in length between the human arm and the longer animal foreleg. Forman had just spent months working without extensions on Little Panda, and preferred not to use them. “When a bear walks,” Barrington Holt explained, “it lifts its front foot and tucks the paw under. That’s easy to do when walking on your hands, but much trickier with leg extensions. Since there were no side views of our bears walking on all fours, we figured we could get by without them.” A set of front paws with rubber pads inserted in the palms allowed Forman to walk on his fingertips, providing additional height and flexibility. A second set – worn like gloves – was designed for closeups of the bear reacting to the vehicle. “We nearly always do two pairs because the ones that are used for walking get a lot of abuse and need to be very durable, whereas the others are good for more subtle manipulations.” Back paws were sculpted on a pair of sneakers so that the actor could slip in and out of them easily.

The bear suit was designed for optimal safety and comfort. “That’s a very big issue with us,” said Barrington Holt. “We’ve heard far too many stories about actors trapped inside costumes that were killing them, where it took half an hour to get them out. In the costumes that we build, the performer is very accessible. The front opens up easily, the head comes off very fast and the costume slips off the shoulders.” Fans were also on hand to pump cool air directly into the suit. “You’ve absolutely got to make the performer your number one priority. It doesn’t matter how good the costume is – if he’s not happy, everything else goes.”

The intense, two-day shoot took place in the mountains above *Lake Tahoe*. “Henry wanted to film during the golden hour, when the sun was low in the sky and the light diffused,” recalled general manager Matt J. Britton, “which meant that we had just two or three hours of optimum light each day.” It also meant fast and furious work for puppeteer Alan Troutman and for Forman, tasked with portraying all three bears. “Dave would do a shot in one position, immediately rush around to his second position before the light changed, then rush back to the third position – all in ninety-five-degree weather, wearing a heavy fur costume.”

The popular Honda commercial may help to dispel the notion that Jim Henson’s Creature Shop is exclusively in the business of creating fantasy characters. “It’s very frustrating for us,” Barrington Holt revealed, “that in the United States, everyone connects us with the Muppets, while virtually nobody is aware of all the realistic work we have done. We never built the Muppets – but we have been creating very sophisticated animatronics for fifteen years.”

QUICK CUTS AN ENDANGERING SPECIES

article by Estelle Shay

Like the nightmare images that bore his signature in *Alien*, Swiss surrealist artist H.R. Giger's dark illustrations once again provide the basis for science fiction thrills. In *Species*, a young girl born of an ill-begotten genetic experiment combining human and extraterrestrial DNA, escapes from a government lab just as scientists are preparing to terminate her. Exhibiting a growth cycle that is anything but ordinary, the alien – known simply as Sil – begins taking on more horrific forms as she searches for an ideal mate. To translate Giger's designs for the humanoid creature into three-dimensional reality, director Roger Donaldson and visual effects supervisor Richard Edlund enlisted the aid of XFX.

"What distinguishes Sil from the creature in *Alien*, or any of the hundred *Alien* rip-offs, is that she is female and beautiful" noted XFX founder Steve Johnson. "She is also completely translucent, which is typical of Giger's work. So we were tasked with building a life-size animatronic character that you could see into, with layers and layers of internal organs. In that respect, it was like nothing that had ever been done before." Johnson and XFX art director Bill Corso were given just ten weeks in which to deliver a full-body puppet for filming.

Sculpted by Mike Hosch and Norman Cabrera, the creature was vacuformed in clear plastic, then cut into pieces to determine where the points of movement needed to be. While foam rubber was used for soft areas such as elbows, knees and hands, a somewhat unorthodox fabrication made up the translucent expanses of torso, hips, shoulders and neck. "Nothing was working, and we were running out of time," recalled Johnson, "so, in desperation, we tried nylon hose, grafting it in large sections with a few floating vacuformed pieces to help maintain the shape. It was a wonderful solution – so stretchy that no matter how the creature moved, it didn't wrinkle like fabric. And, coated with K-Y jelly, it was virtually transparent – like a clear, fleshy membrane." An endoskeleton fit within the clear outer shell. "For that we used what we called 'Giger-flex' – an odd assortment of rubber hoses, plastic fabricated pieces and disks to indicate cartilage-like, repetitive bone formations."

Mechanical design supervisor Eric Feidler developed both marionette-style and rod actuated mechanisms for body articulation, with cable functions controlling the head. "Since the skull was visible behind the clear outer face, we thought it would be interesting to mechanize the head on the inside," Johnson observed. "So we put plates under the outer skin on top of the skull to effect brow movement, and added bands of texture under the cheeks." Two sets of teeth – an outer set and inner set, both capable of moving independently of the skull – added to the unearthly look, as did eyeballs equipped with a refraction grading that could change their color, and eyelids that blinked both up and down and right to left.

Especially striking was Sil's hair, executed by Shaun Smith and Brian Goehring. Resembling an Egyptian headdress, it consisted of thirty-six vertebrae-like strands protruding gracefully from the back of the head, each covered by an outer translucent skin. "We explored the idea of mechanizing

the strands independently for a Medusa effect,” recalled Johnson, “but when that proved unfeasible, we ended up making three different hair constructs. Two were nonarticulated – one in a dormant shape and the other fanned out like a peacock tail – and the third, our hero version, had a double tentacle mechanism concealed under the strands to provide a snake-like, four-way movement at both the base and top. The strands were elasticized and attached in several places so that they functioned as one unit, moving in a graceful S-curve whenever Sil whipped her head around.”

Supplementing the puppet were three foam rubber suits, designed to be worn by actors. Fabricated by Lynette Johnson, Dale Brady and Tamara Carlson, and painted by Moto Hata, the suits were used for several fleeting shots of Sil, and in a dream sequence, shot underwater, in which Sil envisions herself in alien form copulating with a male counterpart. The sequence also required fabrication of a male creature suit. “We broke up the human form on the male,” said Johnson, “with a series of twelve-foot protuberances – like enormous crab claws – extending down the back, and a penile tentacle protruding off the back of the head.” The suit-clad actors were so buoyant that they had to be fitted with lead weights to keep them underwater.

For a climactic birthing scene, a special full-body animatronic Sil was built with a chest that arched and cleaved open. Access to the back of the chest enabled puppeteers to operate a mechanical baby which emerges from inside a highly elastic membrane made from a hot-melt adhesive. “By using the membrane, we didn’t have to create a perfectly realistic baby – which would have been difficult to do,” said Johnson. “Once Sil sets it on the ground and begins to peel off the chrysalis, the camera cuts to a real baby.”

For another scene in which the ten-year-old Sil physically transforms for the first time, Johnson and Edlund conceived an effect that combined makeup and computer graphics. As the transformation begins, Sil’s face suddenly comes alive with the bulging and squirming of small protuberances under her skin. Eventually they erupt in worm-like, translucent strands that shoot up to the ceiling to form a chrysalis. “The transformation happens after Sil has been gorging herself with food,” Johnson explained. “That gave us an excuse to create a fat makeup for the actress.” Underneath the prosthetic appliances, keyed by Bill Corso and Kenny Myers, were planted twelve or so semi-flexible buttons made of flexacril. “We covered them with a section of painted condom, followed by a section of slimed-up nylon hose, and attached a monofilament to each device. Then we replaced the appliances, scored them and glued them back together with the monofilaments protruding. By pulling on the monofilaments we could manipulate the devices so they squirmed and stretched and, after a point, popped through the skin as slimy-looking worms.” Computer imagery provided by Boss Film Studios continued and completed the effect.

To create the fully formed chrysalis, Johnson abandoned conventional sculpting techniques. “Rather than relying on a mechanized model, we fabricated the cocoon using multiple layers of clear, thin polypropylene. We found that we could hand-manipulate the plastic – which is as malleable as clay – by cross-pulling it to create shapes and textures with layers of puckers and protrusions that looked very Gigeresque. Finally, we brushed colored gels over everything to create highlights and shadows.” Animating the construct required twelve operators and was accomplished using forced air and monofilaments.

Johnson and his team would later apply their polypropylene technology to a subsequent scene in which government scientist Xavier Fitch (Ben Kingsley) returns to the lab to create a pure form of the alien so that he might determine how to destroy Sil. With astonishing speed, the lab specimen goes from single fertilized cell to a ten-foot-tall chrysalis. “For shots of the creature growing in the petri dish,” explained Johnson, “we injected air through a soapy mixture of methylcellulose to create bubbles that looked like cells forming. Then we fashioned several stages of our polypropylene chrysalis – showing it filling the dish and later overflowing into a containment box. We experimented with the air and monofilament method of articulation – trying reverse- and forward-flow suction and inflation. Because the monofilaments were clear, we could film the chrysalis backlit and you would see this thing dance with a hundred tentacles twitching, without ever seeing what was operating them.”

As the chrysalis splits open, a phallus-like creature emerges. “It was just a weird Gigeresque thing resembling a snake mouth that we fashioned from a hot-melt vinyl,” commented Johnson. “No head – just three twisting tails combining into one. We articulated it by putting it on a drill motor and dragging it backwards while running the drill to create a bizarre spinning movement. Then we reversed the film, so it looks like the creature is moving forward.” Retreating from a flamethrower attack, the creature crawls up into some ceiling pipes and once again transforms – this time into a ten-foot-tall monster chrysalis, fashioned once again as an air-operated polypropylene bag.

Despite the herculean task of completing an enormous assignment on a tight deadline, *Species* proved a watershed project for XFX. “I did a lot of research at the start, and had a revelation of sorts,” remarked Johnson. “I came to the conclusion that our industry has gotten so stuck in accepted techniques that we may have forgotten what creating reality is all about. In *Species*, nothing we did was standard technique – but it was, hands down, the best work we’ve ever done.”



From a design by H.R. Giger, Steve Johnson and his XFX team constructed an animatronic alien for the science fiction thriller Species.

QUICK CUTS

CAPTURING AN ALIEN SPECIES

article by Estelle Shay

When producer Frank Mancuso, Jr. approached Richard Edlund of Boss Film Studios about overseeing the visual effects for *Species*, Edlund was quick to accept the challenge. “We had been working for more than a year on developing and testing a new motion capture system,” noted the Oscar-winning effects veteran, “and we were looking for an opportunity to take it to a higher level.” In Sil – the exotic, translucent alien born of H.R. Giger’s dark vision – Edlund had found his ideal subject. Sil would ultimately be realized through a combination of animatronics and computer generated imagery, with motion capture technology contributing overwhelmingly to the process.

Since director Roger Donaldson had minimal experience working in the digital realm, Edlund and co-visual effects supervisor Jim Rygiel set out to convince him that motion capture technology would greatly enhance his comfort level. “We had begun our own R&D process,” stated Boss senior vice president of production Ellen M. Somers, “in response to the huge number of scripts coming to us that involved nonhuman type characters. We knew we had to get to the forefront of computer animation. Recognizing that the interface is always a problem for the director – because there is no physical puppet to watch – we wanted to move computer animation in the direction of interactive real time, with the ultimate goal of creating a virtual studio where a director can literally walk in, direct a computer character with full body and facial motion in a temporary composite, and leave the same day with a videotape to take back to his editing room.”

The advantages of motion capture were also in its agility and speed. “The attitude of our system, from early development on, was very much geared to finding a way to accomplish a large volume of character animation in a short amount of time,” Somers remarked. “Our schedule on this film was extraordinarily tight – a very short preproduction and a postproduction of only about sixteen weeks. With nearly twenty shots in an end sequence requiring complex character animation, there wasn’t going to be the luxury of coming back in three or four weeks with our CG Sil, and saying, ‘Is this anything like what you wanted?’ And even though we have some of the best talent in the industry here, it was questionable whether we could even deliver this type of animation within the given time frame.”

Although Edlund briefly considered taking advantage of existing systems that utilized human body capture, the idea was quickly abandoned. “The problem is that those systems can only do what a human can do,” Edlund noted. “We wanted Sil to be able to move in nonhuman ways, leaping around and climbing walls and doing things that humans cannot do. Trying to accomplish that with body capture would have necessitated suspending an acrobat from wires, hooked to all kinds of electronic paraphernalia – which would have been a nightmare to shoot.” Boss’ prototype system, on the other hand, utilized an electronic puppet armature that could be moved to correspond with a live-action background imported into the computer as an image file and played back on a monitor. Special software interpreted the movement data from the puppet, capturing it in the computer and rendering it in real time as a low-resolution, but fairly complex digital character moving in sync

with the background plate. “We felt the puppeteering approach was the way to go, because it gave us the flexibility of making Sil into this very athletic creature. And the beauty of our system is that, although the director determines the character’s basic moves and captures the spirit of the scene, the raw motion capture data then goes to a workstation where it can be manipulated infinitely.”

As the project got underway, Edlund recruited Steve Johnson of XFX to construct a full-scale animatronic Sil for quick cuts and carefully staged closeups of the character metamorphosing into alien form – which she does whenever her emotions are aroused. While Johnson grappled with the considerable mechanical and design issues involved in building an animatronic interpretation of Giger’s drawings, the digital team at Boss geared up for the equally complex task of creating a computer generated counterpart. After digitizing a casting of the outer-shell sculpture provided by Johnson, they began working with a three-dimensional wire-frame model in the computer. Visual effects designer John Mann was charged with determining the creature’s movement characteristics. “How something moves in animation gives you a lot of clues as to what kind of character it is,” explained Mann. “With Sil, the crux of the animation issue was how to make Giger’s essentially humanoid form move in nonhuman ways. Fortunately, in the CG world I could take Sil’s limbs and extend them far beyond the normal range of motion.” Using character animation sketches and storyboards showing the creature in various poses, Mann and CGI integration chief André Bustanoby developed the architectural skeleton upon which the many points of movement would be based.



Richard Edlund – visual effects supervisor and head of Boss Film Studios – poses with a nightmare train model designed and built by H.R. Giger for Species.

To bring the company’s motion capture prototype up to production capability, Bustanoby and master machinist Ken Dudderar designed and built a miniature electronic puppet armature that could incorporate the complex articulation needs of the character. “The Sil armature is a third-generation device,” said Bustanoby. “Our first armature was one the model shop originally made for a dinosaur test in response to a potential project requiring



Boss used computer graphics and an advanced motion capture system to create an exotic and deadly being

enormous amounts of animation input instead of only key-framing. Then we did a cow for a Kellogg's commercial – really our first production use of it. All the while we were learning and making mistakes and seeing where we could improve.”

conceived experimentally through the splicing of human and extraterrestrial DNA.
Boss used computer graphics and an advanced motion capture system to create an exotic and deadly being conceived experimentally through the splicing of human and extraterrestrial DNA.

Ensuring that the armature would match the full-size robotic proved no simple task. “I looked at a lot of the classical CGI skeletons that are used for inverse kinematics,” recalled Bustanoby. “I met with Mike Hosch – who sculpted the Sil puppet at XFX – to discuss the creature’s anatomy, where the joints would be if she actually existed as a living, breathing thing, and how they would interact and move. We had to have extreme stretchability for doing gymnastic type splits – joints that could go well past 180 degrees – so that the armature would have the necessary dynamics.” Since the design criteria for building a full-size robotic were quite different from those of designing the armature, Bustanoby employed Johnson’s designs merely as a starting point. “I took the Viewpoint wire-frame used as the basis for the CG model and made, in Alias, a very accurate skeleton. Then I took that geometry – the XYZ locations of each joint – and transferred it into my CAD software and proceeded to design the armature.”

Precise calibrations were needed to ensure that the geometry of the armature – the length between joints and how they were all configured – matched the CGI character as closely as possible so that the two would operate in sync. “When you’re using a hard armature to drive just rotational data in a computer,” Bustanoby observed, “if any length is even slightly off along the entire chain of joints, the movement will not look clean. So that’s where the machine shop expertise and engineering come into play.”

The armature was configured for a shelf life beyond the immediate character. “With our first- and second-generation armatures, we were locked into a particular configuration once they were built,” stated Bustanoby. “I wanted this one to be like a tinker toy set that you could break down into its component parts and basically reconfigure in an infinite number of ways. So we constructed it as sort of a smart armature, with each joint a self-contained unit equipped with its own circuitry. That way, we could pre-program it, throw it in a box and use it later to create a new character in a fraction of the time it would take to build one from scratch.”

Each of forty individual body joints contained a digital converter, and the armature was equipped with five microprocessors that could relay movement data to a computer in real time. The electronics hardware and software system was designed by engineers Jeff Platt and Mike Wise, and technician Donny Sierer. “We needed to create a ‘noise-free’ puppet,” said Platt “which was difficult since we were using analog sensors and we required twelve bits of resolution. We achieved this by mounting a digital converter on each joint. We then used a serial bus interface to send the data to the SGI station at twenty-four samples per second.”

Charged with creating the specialized software needed to drive the motion capture system, director of software development Shahril Ibrahim and software engineers Hiroyuki Miyoshi and Gautham Krishnamurti used Wavefront Preview reengineered for greater speed and versatility. Pushing the envelope of motion capture technology, they improved the software in countless ways. “One of the things we can do now, that was not possible before,” noted Ibrahim, “is combine movements captured from different takes. So if a director likes how the legs move in a particular take, he can say, ‘Give me just the leg motion, and let’s redo the rest of the body.’”



An electronic puppet was developed to encode the character's body movements in real time. Facial articulation was achieved through the employment of a linked facial capture system.

Ibrahim and team also massaged their software to improve the appearance of the low-resolution character viewed on the monitor. “Initially our motion capture character was simply a geometric shape with paddles for hands,” Ibrahim noted, “but by the end of the motion capture period, we were able to achieve a much higher resolution.” Another enhancement was the incorporation of camera tracking capability. “In four or five of the motion capture shots, the camera needed to be moving. So we wrote special software in house that allowed us to track how the camera moves in a scene without the need for cumbersome motion control. We then applied that technique to our motion capture so that the virtual camera or the camera pass that went around our digital Sil would precisely match what was shot on the live stage. That way our CG character would be locked to the background and not look as if it was floating in space.”

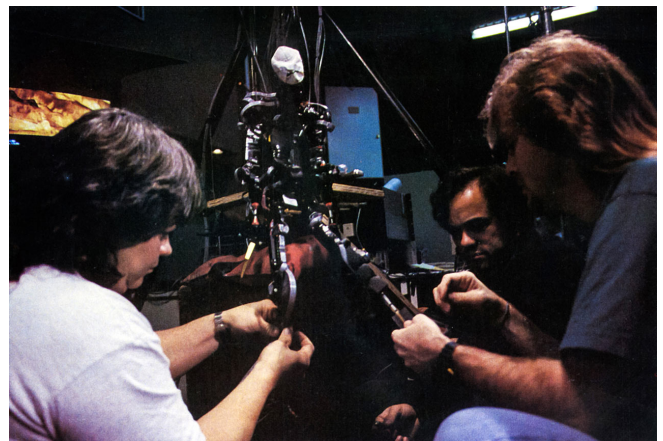
The flexibility of the software was such that it could also accommodate changes in camera orientation even after the motion capture was finished. “When the ending of the film was altered somewhat,” recalled Ibrahim, “the whole setup of our end sequence changed slightly; and instead of the camera facing Sil one way in a particular shot, Roger wanted it to be facing her from the opposite direction. Without having to redo the take that had already been selected, we could fix it by simply shifting the virtual camera to the other side.”

As the motion capture system came together, it was pressed into service for the complex animation demands of the film’s climax, in which Sil – fully metamorphosed – confronts the government team charged with destroying her. Under Donaldson’s direction, lead motion capture puppeteer Craig Talmy manipulated the Sil armature on a space representing a half-scale version of the cavern set where she has gone to give birth. “My job was to correspond the puppet’s performance to background footage of the cavern,” explained Talmy, “which consisted of prerecorded film dumped into the computer and played back at a given frame rate. If a shot required a lot of intricate moves, we could slow the playback down to maybe three frames a second – whatever was needed to get the take.” Talmy and his crew often accomplished more than one hundred takes daily, which translated into at least one usable shot per day. “The system allowed us to accomplish far more than a standard CGI department doing key-framing. Plus it gave the director room to reject something or change his mind about a shot without slowing things down.”

During the motion capture period, the digital team made yet another significant breakthrough in the form of a separate facial capture system. Two months in the making, the system employed technology similar to that developed for the body armature, allowing Donaldson to direct Sil's facial expressions in real time for the motion capture shots. A rig designed and built by Dudderar and Wise and consisting of a tabletop hand-armature device – much like a puppet rig – featured right- and left-hand controls that manipulated mouth, lips, eyes, nose, brows and cheeks on a digital Sil face. In their full-weighted position, the control channels were preprogrammed to produce up to thirty distinct facial expressions; however, by combining poses and manipulating sliders that controlled the weight of each movement, operators could produce virtually unlimited nuances. "Our puppeteers preferred the hand control approach over optical approaches that use human facial capture," Ibrahim stated, "because they felt they had far greater dexterity with their hands, and moves could be repeated easily."

To add the facial capture to the existing shots, a second pass was made on all of the Sil motion capture sequences, with Donaldson directing the puppeteers on the kinds of emotions he wanted the creature to exude. Eleventh-hour improvements to the software enabled Ibrahim to link the facial capture into the body capture system. "Our first attempt at the software had the head unattached to the body, like a mask sitting in space. But we soon realized that trying to visualize what facial expressions were needed when we couldn't see the entire shot was too difficult." The solution entailed grafting the facial capture onto the existing body capture so that the image of the full creature moving against the live-action background could be viewed in real time.

As takes were approved, animators enhanced the motion capture performance with the addition of secondary motions – such as delicate hand movements, breathing movements or positioning of the feet – before transferring the captured data over for final rendering. To render the translucent, multilayered Sil in high-resolution skins, digital artists created more than a hundred individual color and texture maps. The need to precisely match the virtual Sil with her animatronic counterpart made the task even more arduous. "At XFX, Steve covered his finished puppet with K-Y jelly to make the clear plastic appear more life-like," commented Ellen Somers. "Duplicating that look on our computer generated version took an entirely separate R&D effort. Our programmers ended up writing what we now refer to as 'K-Y shaders' to precisely mimic the light refraction and specularity changes caused by the jelly."



Electronics technician Donny Sierer, electronics supervisor Jeff Platt and head of physical integration André Bustanoby ready the motion capture puppet for a shot.

Once the Sil motion capture was completed, the visual effects team faced a whole other animation challenge in the form of Boy Sil. Born to Sil in the cavern, her offspring rapidly metamorphoses from human infant into juvenile monster, meeting an untimely death when he is impaled on the end of a flamethrower and pitched over a ledge. Conceived entirely as a computer generated effect, Boy Sil was designed by art director John Mann, using Sil's digitally engineered humanoid form as a

basis. "Our worst fears about adolescence are embodied in Boy Sil," Mann commented wryly. "He's sort of an awkward, testosterone-filled acne boy – half-human, half-Sil and not quite fully formed." Mann imbued the creature with several distinguishing characteristics, including an elongated, gnarled-looking head that appears only partially formed and a chest adapted from Sil's torso, but with the breasts eliminated in favor of a phallus in the sternum area. The new head and chest were sculpted, digitized and rendered in the computer. "Then we attached them to the existing Sil body and pulled, poked, yanked and stretched her. We elongated the legs, took off the stomach area so you could see some half-formed muscle strands within the new torso, shrank the rib cage and made the arms more gangly, with one arm shriveled and malformed."

Motion capture once again proved valuable in animating the creature, especially since the effects team was able to use the existing Sil armature instead of having to build one from scratch. "Boy Sil had two things that made him unique," Ibrahim explained. "First, his movements were more insectlike than Sil's, requiring slightly more flexible joints and a reconfiguration of our Sil armature for greater range of motion. Secondly, he had closer interaction with the real actors and props, which made the motion capture trickier." To achieve a realistic interaction, puppeteers used tiny motion capture props and placed marks on the set to estimate positions of the real actors in the scene. "We built a small, scaled-down flamethrower that we could impale our puppet on and swing around so we'd get a realistic movement." Adjustments were also made to the low-resolution digital image viewed by the director. "We stretched the limbs on the character so that what Roger viewed on the composite screen was an accurately proportioned image of Boy Sil, rather than Sil. We also made him highly transparent for the purposes of the motion capture, so that we could see the action going on behind him and make sure all the movements lined up nicely."

Although motion capture was indispensable in animating the climactic end sequence, a number of computer generated shots for earlier sequences would be accomplished by the digital team with standard key-framing and compositing. In those instances, artists relied heavily on 2-D or 3-D computer graphics in combination with robotic effects to portray the human Sil transforming into alien form.

With *Species*, Edlund and his team were able to achieve a new level of realism in computer generated character animation by pushing the limits of motion capture technology. "We learned an enormous amount on this film," Edlund reflected, "and there's no question that motion capture will have a major impact on our industry. It may, in fact be a prelude to a new era of digital actors and digital stuntmen in film – because as visual effects become more doable, more reliable and quicker with digital technology, boundaries will continue to break down between the effects movie and the ordinary film. The grammar of filmmaking is expanding to incorporate visual effects in a way we've never experienced before. Who knows what will be next?"

QUICK CUTS

BONNIE AND CLYDE

article by Jody Duncan

Hideaway, a TriStar Pictures adaptation of the bestselling novel by Dean R. Koontz, explored issues of the afterlife and the essence of good and evil. In the story, Hatch Harrison (Jeff Goldblum) dies in a car accident, but is resuscitated in a cutting-edge medical procedure, only to discover himself psychically linked to another recent resuscitee, Vassago (Jeremy Sisto), a serial killer with a bizarre artistic agenda.

Effects sequences in the film depict the surreal post-death journeys of both men, as well as a climactic battle between the force of good residing in Hatch and the force of evil festering in Vassago. So crucial were these sequences that Sony Pictures Imageworks' effects producer Camille Cellucci and visual effects supervisor Tim McGovern were among the first people brought onto the project. Cellucci and McGovern spent five weeks visualizing the sequences with director Brett Leonard, visual effects co-supervisor Aileen Timmer, storyboard artist Keith Tucker and conceptual artist Jon Townley. "The five of us developed the mythology behind these death journeys," Cellucci recalled. "It took a lot of thought to determine exactly what would happen to the characters after they died, and how we could reveal this journey to the audience." It was during these brainstorming sessions that the dark and light forces – introduced during the death journeys and more fully revealed in the final battle – were defined. "Rather than referring to them as the 'light being' and the 'dark being,' we named them 'Bonnie' and 'Clyde.' Bonnie is an ethereal, beautiful essence, while Clyde is the force of evil. For reference in designing Bonnie and Clyde, we put together a binder with about three hundred images of masks from indigenous cultures around the world."

A key element in the effects design was the photographic work of Jerry Morawski. "Jerry does complex light effects photography," Tim McGovern explained. "It is very organic, and it seemed well suited to be the basis for Bonnie. We were also able to use aspects of it for the death journey tunnels.

We scanned in Jerry's photographs, altered them as needed, and actually created three-dimensional geometry from the images. Then we mapped the photographs onto that geometry to create a very complex three-dimensional environment."

Both death journeys were designed to follow a logical progression that would wholly involve the audience in the experience. "We thought of the death journeys as a ride-film," McGovern stated. "Instead of having the whole thing take place as a POV of the person who has died, Brett wanted to have shots that revealed the person and gave some suggestion of his spirit form." The spirit forms of Hatch and Vassago were computer generated. "We scanned both Jeremy and Jeff doing a variety of facial expressions. Then we animated between those expressions and also created new ones by modifying the data." The bodies of the spirit forms were modeled from scratch, using measurements gleaned from having the actors stand in front of a grid board.

The death journeys also required a succession of changing environments. Images based on the Morawski photography were created by computer graphics supervisor Jerome Chen. "We created

different environments as the journey progressed to suggest that the subject was passing through multiple layers, breaking through membranes and peeling away the physical world as he moved toward the spiritual side,” McGovern commented. “To make some of the environments more surreal, we had to keep knocking the resolution down and increasing the motion blur until we got the feeling we wanted.”

Toward the end of his death journey, Vassago approaches the judgment gate, another image derived from Morawski photography. According to the afterlife mythology devised by Leonard and his team, the gate is neutral when the subject arrives. Then, at the moment of judgment, it transforms either into a light source which embraces the good soul or a bladed shredder that makes mincemeat of the wicked. Clyde makes his first appearance as Vassago’s soul is shredded and thrown into the bowels of hell. “A pullback reveals the writhing souls that are the core of Clyde,” said McGovern. “There is a membranous mass, and hundreds of figures moving and writhing within the body hive.” Inspiration for the hive was provided by an aerial photograph of an Indonesian monkey chant ritual, as well as microscopic photography of growing cancer cells. Reference for the writhing souls was found in photographs of bog people. “In the Middle Ages, some cultures would take human sacrifices out to a peat bog, beat them on the head and throw them in. Because of the composition of the bog, the bones in these bodies would be melted away, leaving a tanned human skin that preserved every horrific detail.” Faces for the hell-bound souls were modeled after the native masks. “We scanned in all of the mask photographs we felt were appropriate for Clyde. In some instances, we actually sculpted them in clay, then digitized the clay model in the computer. For most of them, however, we created polygonal models from scratch, using Alias and Wavefront Explore software.”

To impart writhing movements to the bodies, motion capture technology was employed. Camille Cellucci, who had a background in movement that included training with mime artist Marcel Marceau, was drafted to perform the movements. “Motion capture allows a director to direct a computer animated character in real time,” stated Cellucci. “We had a computer graphic character – a simpler version of what was going to be the final character – on the monitor. And we had sensors attached to specific points on my body. Through those sensors, any movement that I did was translated to the CG character on the screen.”

“We took that motion data,” said McGovern, “and multiplied and offset the takes that we liked so there would be a lot of variation in the animated characters. We wound up with about 250 writhing souls. We suspect there are more people than that in hell; but because an average frame took six hours to render, that was how many we could do within our schedule. To the basic animation of the entire form we added the animation of thirty to forty masks pushing out. The masks grow and their mouths open and their eyes and brows move. All of that was key-frame-animated by Tim Miller. His wire-frame animation was then handed over to Louis Ceterelli who did the lighting and color on the body hive. Louis used a software program created by Arnaud Hervas to make the masks gain more and more detail as they emerged, then deemphasize and lose information as they moved back toward the core.”



Sony Pictures Imageworks used computer generated imagery to create post-death journeys and spirits representing good and evil for the supernatural thriller Hideaway.



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Bonnie is first revealed as Hatch ends his death journey. “Even though Bonnie was the force of goodness,” McGovern said, “we wanted to make her a warrior – to show that she was just as strong as Clyde – so we included what looked like shards of crystal into her design and gave her a headdress that was like a warrior’s helmet.” Bonnie’s face was an icon mask embellished in the computer by digital artist Allen Edwards. Her body consisted of many layers of computer modeled geometry mapped with further layers of the modified Morawski photography.

At film’s end, Hatch confronts Vassago in the subterranean hideaway where the killer has reconstructed a gruesome body hive. As the two human adversaries fight, Bonnie and Clyde engage in their own battle overhead. To place the digital characters in 3-D space, the set was measured precisely and recreated in the computer. “We kept track of where the camera was, and what the focal length was,” noted McGovern. “Then we recreated the camera move in the computer. The production designer agreed to add red lights to the design of the set so we would have something to key into to make our 3-D tracking easier.”

Sony Pictures Imageworks executed sixty-four shots for *Hideaway*, some as long as 450 frames. Leonard and his production team pulled together to facilitate those effects, rather than subjugating them to the realm of afterthought. “This was one of the most collaborative projects we’ve ever worked on,” Cellucci noted. “Gale Tattersall, the director of photography, worked with our animators on the lighting; and Michael Bolton, the production designer, allowed us interaction in terms of how the set was going to affect the placement of our CG characters. Brett included us all the way. I was wonderful to be involved that fully.”



Sony Pictures Imageworks used computer generated imagery to create post-death journeys and spirits representing good and evil for the supernatural thriller Hideaway.

LAUNCHING APOLLO 13

image

article by
Tim Prokop

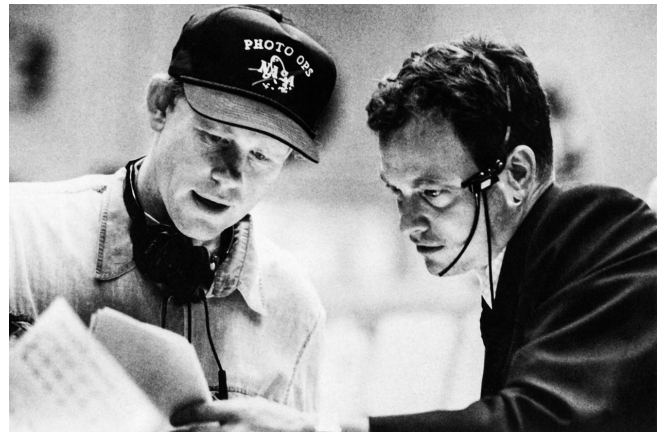
They were not a superstitious lot, the astronauts and flight crew of NASA's 1970 moon mission. The fact that this was the Apollo program's thirteenth mission, scheduled to launch at 1313 hours, military time, and to begin orbiting the moon on April 13 held no significance for these practical men of science. After a disastrous start with the fiery deaths of astronauts Gus Grissom, Ed White and Roger Chaffee during a launch test, the Apollo program had recovered and become a stunning success that culminated with Apollo 11's landing on the moon in 1969. With the similarly glitch-free lunar landing of Apollo 12, the general public had come to regard the program as just another mundane fact of twentieth-century life; and, by 1970, reports of its progress were most often relegated to below-the-fold news stories.

In a most dramatic fashion, the events of Apollo 13 would serve to remind an indifferent public, at least temporarily, that rocketing men into space is never a routine matter. The first sign of trouble came, after a by-the-book launch and an uneventful fifty-six hours in space, with commander Jim Lovell's calm transmission to mission control: "Houston, we have a problem." As the whole world would soon learn, the report was a case of extraordinary understatement.

With the routine stirring of the service module oxygen tanks, faulty wiring had caused an explosion which resulted in catastrophic damage to the ship. As the precious gas leaked out into space and oxygen levels within the command module plummeted, the three astronauts on board – Jim Lovell, Fred Haise and Jack Swigert – were forced to shut down the crippled ship and relocate to the lunar excursion module, which for the next four days would provide tenuous life support. The entire world looked skyward and prayed as NASA scientists worked frantically to bring the beleaguered men home. Against incredible odds, and in the face of one calamity after another, the compromised command module finally splashed down in the South Pacific on April 17. Apollo 13 had not accomplished its mission – but the titanic effort to bring its crew back alive may well have represented NASA's finest hour.



*An ill-fated moon mission is chronicled in director Ron Howard's *Apollo 13*, starring Tom Hanks, Kevin Bacon and Bill Paxton as astronauts Jim Lovell, Jack Swigert and Fred Haise, all but given up for lost when their spacecraft suffered severe damage due to an on-board explosion. An extraordinarily committed effort by the mission control ground crew resulted in the astronauts' recovery four days later. Rather than employ NASA stock footage, Howard boldly opted to depict the grander aspects of this historical drama entirely through visual effects created by Digital Domain.*



*On the mission control set, Howard confers with actor Gary Sinise who plays astronaut Ken Mattingly, bumped from Apollo 13 just days before launch due to exposure to measles. Filmed with the cooperation of NASA and the guidance of many of the principals involved in the real-life drama, *Apollo 13* recreated mission control and the pertinent spacecraft in minute detail.*

Apollo 13, a Universal Pictures release from director Ron Howard, chronicles the historic space mission in a film that is documentary-like in its accuracy, yet as suspenseful and compelling as the best science fiction adventure. What makes its skillful recreation of the event even more extraordinary is the fact that, unlike previous films recounting America's space program, not one shot of NASA stock footage was used in its making. From the awe-inspiring launch sequence to the suspenseful splashdown, every significant moment of the *Apollo 13* mission was created through a combination of live-action photography on sets and full-scale mockups, practical effects, motion control model work and computer generated artifice.

Providing the effects for such an epic, high-profile film was an ambitious undertaking, but one which every large-scale effects facility in the industry was eager to attempt. From the outset, it was apparent that *Apollo 13* would offer ample opportunities for creating memorable, state-of-the-art effects; in addition, it was the kind of high-quality, prestige project that simply does not come along very often, boasting a top-of-the-line director noted for his solid understanding of visual effects, an Academy Award-nominated director of photography in Dean Cundey, an effects-laden, intelligent script by William Broyles, Jr. and Al Reinert, and a talented acting ensemble that included Tom Hanks, Kevin Bacon, Bill Paxton, Gary Sinise, Ed Harris and Kathleen Quinlan.

Armed only with a set of rough storyboards, Ron Howard and executive producer Todd Hallowell, a former production designer, met with various effects houses to determine which would be best suited to providing *Apollo 13*'s spectacular images. "You sign on to do a picture, and then you figure out the solutions to your problems," commented Hallowell. "At the beginning, Ron knew what he wanted in the movie, and we had some vague ideas about how those shots might be achieved, but we had no thoughts about the specific effects that would be involved. Just as I had done when I first read the script for *Backdraft*, I looked at this and thought, 'How are we going to do this?' I had no idea at first. On films like this, necessity leads to invention."

If necessity was the mother of invention for *Apollo 13*, Digital Domain, the visual effects company co-founded by James Cameron, Stan Winston and Scott Ross, would serve as the midwife. In existence for only two years, the young company had already made its name in the industry with its startling effects for Cameron's *True Lies* and Neil Jordan's *Interview With the Vampire*. "I think there are only a few companies who could realistically be asked to do a project of this size," observed visual effects supervisor Robert Legato. "Because of *True Lies* and *Interview With the Vampire*, we were in the running. Neil Jordan was nice enough to talk to Ron Howard about us; and it was partially because of that very gracious phone call that we got the opportunity to meet the challenges involved in creating the effects for *Apollo 13*."

Also instrumental in landing the job for Digital Domain was Cameron himself. "Ron and I had breakfast with Jim," recalled Hallowell, "and he promised to be as involved as we needed him to be. As it turned out, he didn't have to be involved all that much because the team he assembled to handle the work was just extraordinary. The first time we sat down with Rob Legato, we went through hundreds of first draft storyboards and he basically proposed a different solution for every problem. There wasn't a blanket, 'Oh, we'll do that with computer generated images,' as if that is somehow the solution to all filmmaking challenges. Each shot was considered in and of itself. Rob was as concerned with the storytelling as he was with the effectiveness of each individual shot,

which made him an ideal supervisor for this project. He has a real filmmaker's perspective – and that was tremendously helpful, because this movie was not just about individual shots; it was about how those shots fit into the overall context of the film.”

As Legato and his team delved more deeply into planning, it became apparent that Howard viewed his storyboards as mere jumping-off points, rather than fully-realized, shot-by-shot concepts. “Ron and I went over the storyboards together,” Legato recalled, “looking for ways to improve on the shots. It wasn’t a matter of: ‘Here are the storyboards. This is exactly the way the shots should look.’ It was more like: ‘Here’s a great starting point. Where do you think we should go from here?’ That gave me the freedom to look at each shot and consider how it could best be presented. I asked myself: ‘If I was out in space and this rocket went by, what would I look at?’ I might look at one particular panel first; then another section would be interesting, and then I might look over at the engines.”

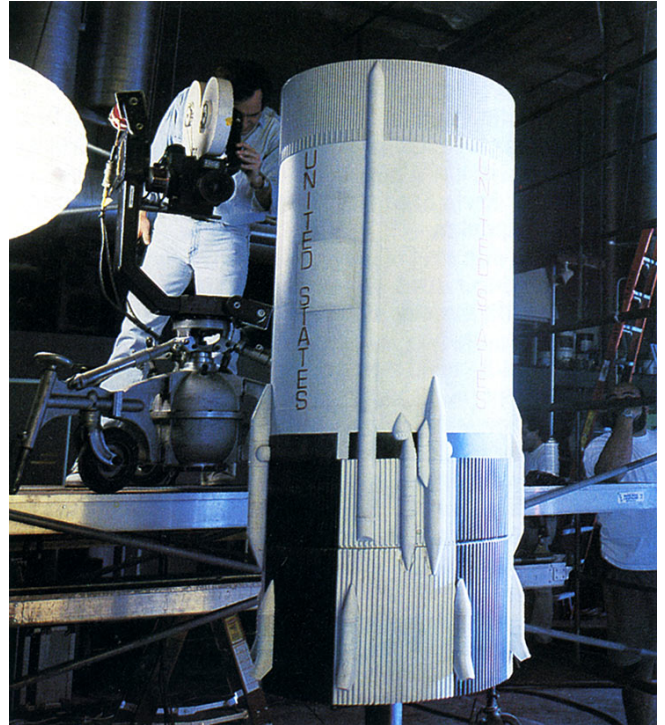
Legato eventually adopted several distinct styles for the visual effects, reflecting the style and pace Howard would establish for each of the movie’s three acts. “During the early parts of the film, the effects consist of big, patriotic looking beauty shots of the Saturn 5 rocket,” Legato explained. “The launch is followed by the beginning of the journey through space, which has a magnificent kind of feeling to it, as if nothing can go wrong, with shots that are long and beautifully choreographed. Then, after the explosion, everything changes to a chaotic, ‘Oh, God, we’re going to die’ feeling. That, in turn, smoothes out as the astronauts go through reentry and finally splash down in the ocean. The story itself has a very nice arc to it; and it was fun to choose different shooting styles for the effects that would help accentuate that.”

The stylistic choices would have tremendous impact on the visual effects effort. To get started in the right direction, Legato and his team reviewed countless reels of stock NASA footage. What they discovered was that, although some of the footage was startling and beautiful, its overall quality varied considerably from reel to reel. “Some of it is fabulous,” Legato commented, “but the lighting is different in every cut, and it ranges from 16mm to 35mm to 70mm military ‘perf’ to film transparency and television coverage. A lot of it is very grainy; and when you really examine it, you see that it was primarily shot for research purposes – with locked-off cameras and without the beautiful camera angles and scenic backgrounds you want for a dramatic film. *The Right Stuff* is a good example of how footage can be used effectively; but that film was structured in a way that allowed you to accept the stock footage for what it is. *Apollo 13* had an entirely different feel to it. Ultimately, Ron Howard had to decide whether we would match our effects to the stock footage, or say ‘forget it’ and start from scratch.”

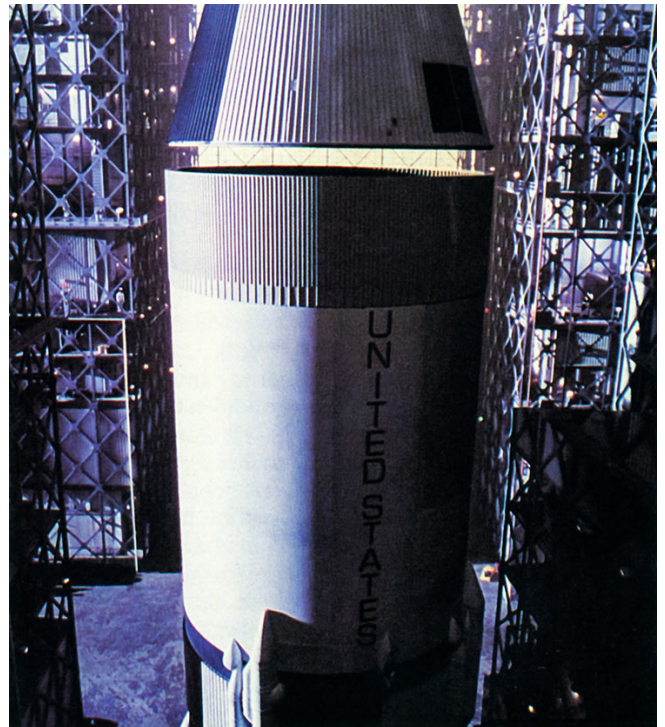
Howard decided on the latter course, and in doing so paved the way for the spectacular visual effects that would help to make *Apollo 13* a standout film. “Once we made that leap and accepted that we wouldn’t use any stock footage, we knew we could light shots the way we wanted to,” said Legato. “We could add dramatic angles and invent new shots based on what we would actually photograph if we could put the camera anywhere we wanted. We decided to copy the style of the NASA footage up to a point, and then introduce camera moves and visuals that you would never find in stock footage. At first the possibilities and freedoms of this approach seemed great; but at some point, the realization hit that we were basically going to have to recreate a half-billion-dollar launch with a model and a fire extinguisher!”

The game plan devised by Howard and Legato was to use a comprehensive blend of effects techniques for *Apollo 13* – including model photography, motion control, practical effects, computer generated enhancements and digital compositing – but to achieve as much in-camera as possible. “I like to shoot everything in-camera unless there’s a specific reason why I can’t,” Legato explained. “Shooting in-camera effects gives me photographic quality right from the start, and also offers the most control over what the finished result will look like. The only way we could achieve the look we were after was by filming a lot of elements in-camera and then adding even more layers digitally. That kind of approach is very involved, so we knew going in that it was going to be a difficult show.”

The difficulty was increased when Universal decided to move *Apollo 13*’s release date forward four months. Suddenly, Digital Domain’s postproduction delivery schedule was cut by almost forty percent. Although the decision was generally viewed as a sign of the studio’s confidence in the picture, the shortened deadline put enormous pressure on the visual effects team, which was left with little time in which to do the kind of research necessary to build accurate, detailed models. With the accelerated delivery date came a new deadline for the film’s trailer. As a result, quarter-scale models for the trailer had to be assembled quickly, with a minimum of reference to guide the effort. “Things were really rushed at the beginning,” model shop crew chief Leslie Ekker recalled, “and we were operating on very thin information. But we did rather well, I think, considering that. Some of the markings on the Saturn 5 aren’t exactly right for this particular mission, and we have six ullage rockets instead of the correct three – but you’d have to directly compare the model with a photograph of the rocket on the launch pad to be able to spot the differences.” Ekker’s research scramble ended when he contacted David Portree, a historical archivist for MSA who, as luck would have it, turned out to be a big fan of



For a scene inside the vehicle assembly building at Cape Canaveral where the Saturn 5 is being assembled for launch, a twentieth-scale rocket – eighteen feet long – was built at Digital Domain and photographed in a miniature set replicating the actual building’s immense interior. Visual effects supervisor Rob Legato prepares to shoot the rocket’s second stage.



The third stage is lowered onto the second inside the vehicle assembly building. Unlike their pristine NASA

space models. “He’s a fanatic,” laughed Ekker. “He was thrilled to be part of the film; and he sent me photographs, booklets, technical manuals, schematic diagrams and a lot of other material which proved really helpful. We also went out and bought every space book you can imagine, both new and used. We ended up with a ton of reference material. I made it my rule that if I saw the same feature or detail in three different pictures, then we could add it on with the secure knowledge that it belonged on this mission.” In fact, Ekker’s research proved so thorough that other members of the effects team were soon turning to him with technical questions. “I became the company answer man. Whenever anyone wanted to know how long an ullage rocket would fire, or where the urine output was on the command module, they came to me. I have to admit, though, I had to look that last one up myself.”

The guidance and availability of consultant Dave Scott – commander of Apollo 15 and the first person to drive on the moon – and Jim Lovell, who actually lived the Apollo 13 experience, also helped to ensure authenticity. “It was pretty daunting to talk with these guys,” Legato commented. “I would get wrapped up in explaining to them what an effect would look like – ‘okay, this is going to happen, then this is going to happen’ – then, suddenly I would stop myself. ‘What am I saying? You know how all this stuff works better than I do!’”

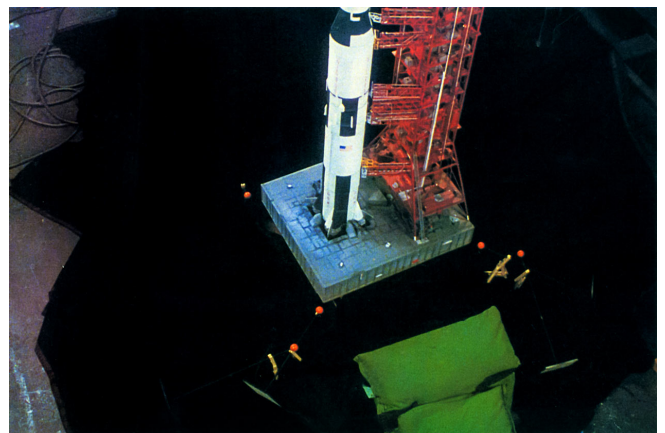
“There were some things we wanted to show in the movie that only a few people on earth have ever seen,” added visual effects producer Jenny Fulle. “So we had a lot of questions for them. What do the thrusters look like in space? How does the ship look as it’s leaving the earth’s orbit? There are only about ten people who know the answers to these questions; and it was great that we were able to ask those people directly.”

Now on a significantly tightened deadline, Legato and the Digital Domain team jumped headlong into producing their nearly two hundred effects shots, many of which would involve motion control model work. To supervise the photography of the miniatures, Legato turned to Erik Nash, with whom he had worked for more than six years while supervising visual effects for television’s *Star Trek: The Next Generation*. “I knew from the start that Apollo 13 was going to be very heavy in model

counterparts; models for the film were subtly weathered and aged to impart a sense of massive scale. The scale of the model was also a factor in the way the models were displayed. The models were built on a walkway inside the building. Actors positioned on a twenty-five-foot-long set were filmed in front of a greenscreen.



The Saturn 5 slated to propel Apollo 13 into space inches its way from the vehicle assembly building to the launch pad on a heavy-duty transport vehicle appropriately called the crawler.



NASA permitted the film company to shoot a helicopter plate of the genuine crawler traversing a runway at Cape Canaveral. Photography of the Saturn 5 – using a five-foot off-the-shelf kit model and a hastily fabricated gantry tower – was then match-moved and composited into the live-action plate.

photography,” said Legato, “and I also knew that there would be so many demands on my time that I couldn’t be there all the time they were shooting. I needed someone I trusted completely; and I had enjoyed such a good relationship with Erik on *Star Trek* that I asked him to join us.”

One of the earliest effects shots to appear in *Apollo 13* is a sweeping helicopter reveal of the vehicle assembly building where the Saturn 5 rocket that will launch *Apollo 13* toward the moon is under construction. As the helicopter POV moves in, the Saturn 5 itself can be seen through an immense open door. Unfortunately for the effects team, the door was closed when the building was photographed, with no hint of a Saturn rocket in sight. Lacking the glitz of some of the other effects in the film, the shot nonetheless presented Digital Domain with the challenge of assembling miniature, live-action and computer graphics elements so flawlessly that the viewer would accept it as reality, never suspecting the painstaking effort that went into producing the final image.

David Norris shot the background plate on location in Florida from an A-Star helicopter fitted with the same Wescam camera system that had photographed the destruction of the Key West bridge in *True Lies*. A two-hundred-pound counterweight allowed the remote-operated camera to swing freely, while gyro-stabilizers reduced unwanted camera movement to a level that allowed the shot to be tracked at Digital Domain. “We had to track the camera motion in the plate,” explained supervising digital artist Judith Crow, “then recalculate that movement so that it could be reproduced in motion control photography of the Saturn 5 model. This technique enabled us to put a miniature of the Saturn rocket into the vehicle assembly building.” Crow accomplished the tracking using in-house software written by Doug Roble that allowed her to extract a move file by positioning a 3-D wire-frame representation of the vehicle assembly building against the background plate. Slight changes in the altitude of the helicopter during filming had to be reproduced exactly for the model to be matched to the building. “It was a tricky process because we had to work with as high a resolution scan as possible, which made everything kind of unwieldy. If we were even one pixel off, it could translate into a difference of inches or feet. So we produced test composites using a wire-frame model of the rocket that was created by Laura di Biagio. We had to make quite a few adjustments before we were finally satisfied with the match and felt we could pass the data on to the stage and our CG department.”

Crow’s three-dimensional tracking information was then used to digitally remove the existing door of the building and replace it with an open doorway. Digital artwork was produced using Prisms, a 3-D image manipulation system. “Laura created the edge of the door, the track that the door rides on, and the door itself in three dimensions to match the actual door of the vehicle assembly building,” explained digital effects art director Kevin Mack. “That was all tracked in 3-D. Then the miniature rocket was put inside.”

The 3-D tracking was accomplished by converting the tracking data to a move file that was then loaded directly into the Kuper motion control system that was used to photograph the miniature rocket. To ensure a more perfect match, slight positional adjustments were made by digital effects supervisor John McLaughlin and digital compositor Pablo Helman using ‘Nuke’ – short for New Compositor – Digital Domain’s proprietary in-house compositing system. To line up the images, McLaughlin wrote a program that expanded the tracking capability of the system, enabling it to track rotational as well as linear movement.

The Saturn 5 model itself was a 1/96th-scale miniature – five feet long – built by Laurence Messier from an off-the-shelf Revell model kit. “That kit had not been sold in the United States since the seventies,” Leslie Ekker noted, “but it was recently reissued in Germany and, fortunately, we were able to get ahold of it. We had originally planned to use that model only in a tracking shot with a lot of motion blur as it rose into the atmosphere; but it looked so good, we wound up getting a lot of use from it.”

The completed shot, including di Biagio’s newly positioned door, was composited by Helman, who used the Flame system to bring all of the elements together. “It was one of those shots where we thought we had the methodology figured out,” said digital compositing supervisor Price Pethel, “but it turned out to be very difficult to extract the actual position of the camera and recreate its movement in three-dimensional space. It took a huge amount of work, but we were finally able to achieve a pixel-accurate match that we could never have come close to with motion control stage work alone.”

Having established the exterior of the vehicle assembly building and the rocket, the film cuts to a shot inside the facility, looking down the length of the Saturn 5 toward its base, where NASA workers and vehicles are dwarfed by its massive size. Unlike the kit model featured in the exterior shot, the Saturn 5 that appears in this first shot of the vehicle assembly building interior was an approximate twelve-foot miniature, representing the first and second stages of the rocket, built from scratch by a team of eight modelmakers working under Ekker and model shop supervisor Pat McClung. The modelmakers also built a thirteen-and-a-half-foot-tall model of the building interior for the shot.

“The rocket model started out as a bunch of appropriately-sized paper tubes and plywood rings that were wrapped with styrene,” Ekker said. “Those tubes were then detailed with ribbing that was molded by James Anka and created by John Ferarri using a vacuform machine that he set up in his garage. The small appendages, pods, connectors and detail that adorn the side of the rocket were all molded and cast as needed for accuracy. I knew that each section had to be versatile, so everything was designed to be easily assembled and modified.” Because the rocket would be required to separate into three stages later in the film, Ekker and his team detailed the top and bottom bulkheads at the join of each section. “Some sections had the sensors, pump hardware, rings, tubing and electronics bays built into the top bulkhead, with removable detail in the center to allow for the passage of an armature pipe.”

The completed model was painted with acrylic lacquer by Laurah Gryalva before graphics such as the ‘USA’ lettering and the flag were added. A complication that became apparent during painting was the fact that the pristine look of NASA’s spacecraft did not translate well in miniature. “Most NASA equipment is kept as clean and as sterile as possible,” explained Ekker. “The launch equipment is assembled indoors and kept absolutely immaculate until it gets out into the weather; even then, it is only exposed to the elements for about a week. If we were to match the real thing exactly, technically we should have painted our rocket models without any weathering whatsoever. But if we’d done that, they would have ended up looking like models. The human eye doesn’t scale anything without a cue; and part of that cue is the way that weathering behaves on the surface of a large object and the way light plays across that weathering. In most cases, we had to weather our

NASA models far more than what was realistic, adding panels, drip marks and burn marks that would help the viewer accept the enormity of the rocket.”

For photography, the model sections of the Saturn 5 were fitted with an armature support and connected to a model mover through expanding arbor side mounts. A variation of the setup was used for the vehicle assembly building sequence, where the rocket and its gantry were surrounded by a configuration of six thirteen-foot-tall towers representing the rocket’s support structures during its construction. The gantry was built of welded steel, with detail provided by pieces of aluminum or plastic. “The gantry and the rocket were difficult,” said Ekker, “because everyone is so familiar with these objects that they have become icons. People may not know what it is they’re seeing exactly, but they have a strong sense of what it should look like; so we had to make sure that we were accurate technically and also accurate in terms of what people remember. We also knew the models were going to be placed in a variety of very difficult matting situations, including being photographed against blue sky, so we placed a lot of emphasis on trying to build them as accurately as possible from the beginning.”

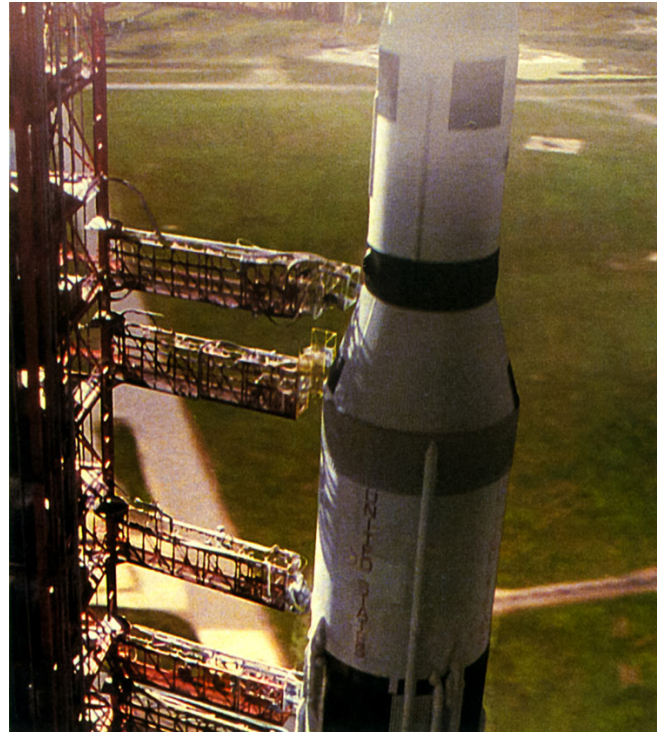


With the monolithic Saturn 5 rising in the background, Apollo 13 astronauts bid farewell to family members the night before launch. For the shot the rocket model was match-moved and composited into a panning foreground plate filmed on location. Lights illuminating the rocket were painted in digitally.

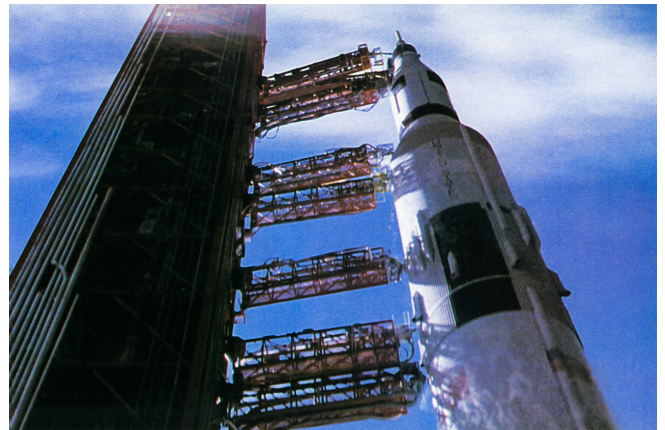
The size of the rocket model – more than eighteen feet tall in its full-stack configuration – posed difficulties when it came time for miniature photography. “Although we have a good size stage at Digital Domain,” stated Erik Nash, “with that large a miniature we were really cramped. Just finding enough space to put a greenscreen up behind the model – and light it to get a decent matte – created a lot of logistical problems.”

“For some shots,” explained Jenny Tulle, “particularly when both the ship and the camera were moving, Erik had to film more than thirteen passes to generate the correct light on the model and a clean matte to separate it out. The model was so large that he sometimes had to use four passes on each different part of the ship, which could have been a real nightmare if it hadn’t been organized. Fortunately, Erik is a great record-keeper, which proved handy for the people who were adding the digital effects.”

Although greenscreen photography was used to generate many of the mattes for *Apollo 13*, Nash and Legato also made wide use of a technique they had developed while photographing models for *Star Trek: The Next Generation*. Instead of greenscreen, the models were lit by black light, and photographed against a fluorescent orange screen through a red separation filter to negate the blue spill inherent with ultraviolet light. “When you create a matte by separating out one of the three primary colors, you use one third of the film stock to generate the matte, which then has the photographic characteristics of that color,” explained Legato. “Bluescreen has the most grain, and so has the lowest resolution of the colors that are available. This can create a noticeable difference between the foreground where blue is present, and the background matte area in which there is no blue. When we came up with the method of photographing models under black light against orange backgrounds, we were under the impression that the red layer was the sharpest layer and would hence give us the sharpest matte. In fact, green is the sharpest layer and red is slightly softer. By accident we discovered that the softer red matte produced less contrast between the foreground and the background because the more extreme layers were present in both the



On the morning of the launch, the Saturn 5 is revealed in a vertical tracking move. A motion control pass on the eighteen-foot rocket was combined with a background digitally assembled from still photos shot at Cape Canaveral. Digital enhancement of the photos included painting out the anachronistic space shuttle and gantry featured in the original stills.



Venting gases and computer generated cloud layers were also added to create an appropriate sense of scale.

foreground and the background. With a red matte, the foreground and the background basically line up one to one and, in essence, average the edge out.”

To populate the vehicle assembly building with NASA workers, twenty-two Digital Domain staff members were filmed in authentic costume against a greenscreen. That photography was then matched to a shot of the building interior model. “The people and vehicles were all filmed with the proper overhead perspective so they could be fitted into the background plate,” said Adam Stark, who composited the shot. “They were photographed performing various tasks and walking around; so I placed them within the miniature and used a matte for the edge of the rocket to make it look as if some of them were walking out from underneath it.” As a final touch, in-camera spark elements were added to the shot, positioned in front of a supposed NASA welder.

The camera pans across the rocket to an elevated walkway alongside it where Jim Lovell (Tom Hanks) conducts a guided tour for a group of dignitaries. The actors in the scene were photographed on the walkway – a twenty-five-foot-long set piece shot greenscreen – as a separate foreground element. That element was matched to the building background plate using Flame software. “Flame has the capability to extract data from the background and apply it to the elements,” explained Stark. “We also developed some interesting software that we used for this shot and several others. The software allowed us to take two plates with different camera moves and reconcile them so that one plate locked completely to the other. We basically worked out a way to extract the camera move from both plates, and then scale one of the moves so it locked up with the other one. In this case, we shot the model element on stage with motion control, extracted the pan information from the live-action, and then applied the background information to the foreground so that they matched up perfectly.”

After the vehicle assembly building is established, the film cuts suddenly to the interior of the Apollo command capsule as a warning light on the console flashes red. The pressure gauge shatters, sending shards of glass tumbling weightlessly through the air before the hatch on the side of the capsule explodes outward. Papers and debris are sucked through the gap as the atmosphere within the spacecraft rushes to fill the void outside. The astronauts float helplessly inside the damaged capsule for a few moments, then tumble through the hatch and into space. The film then cuts to the frightened eye of Marilyn Lovell (Kathleen Quinlan) as she reacts to her nightmare.

Physical effects supervisor Matt Sweeney was charged with creating the effects for the sequence. For the first shot, a prop gauge – created by Larry Fuentes using breakaway glass – was suspended directly over the lens. Two small squibs were set off to shatter the face and send the glass falling past the camera, which was overcranked to make it appear as if the shards were tumbling through space.

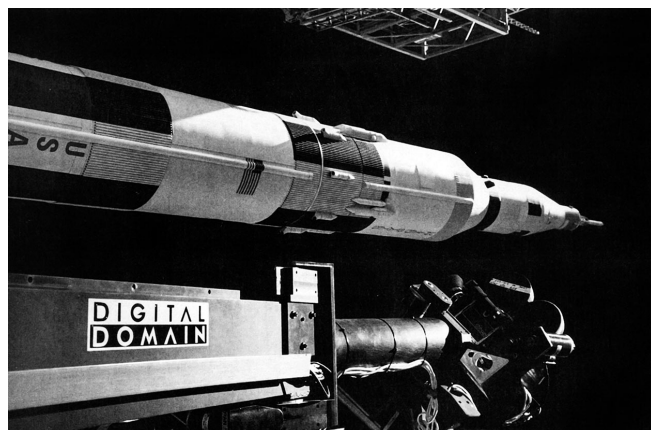
By far the most difficult aspect of the nightmare was simulating the weightlessness of the astronauts, seen in a few brief cuts before they succumb to depressurization and are drawn through the hole in the side of the spacecraft. Shots of the actors in zero-gravity conditions would be featured throughout the movie, the majority captured under harrowing conditions aboard NASA’s weightlessness simulator – a KC-135 aircraft aptly dubbed the ‘Vomit Comet.’ Employed by NASA since 1957 as a means to acclimate astronaut trainees to the zero-gravity effects they would experience in space, the aircraft is a military version of the Boeing 707 which has been gutted and

equipped with padding on its deck, walls and ceiling. The plane first climbs to about 36,000 feet. As it reaches that height, the pilot puts it into a steep dive, racing toward the earth at hundreds of miles per hour. With each climb/dive cycle, or parabola, occupants of the aircraft experience a brief period of weightlessness. “It works pretty much in the same way as a roller coaster, except you fall about 25,000 feet,” laughed Hallowell. “You get twenty-two seconds of simulated zero-g each drop, and then you get hit with 2 g’s as the plane pulls up. You can feel your face pulling back on your skull. It was a pretty trying environment to work in.”

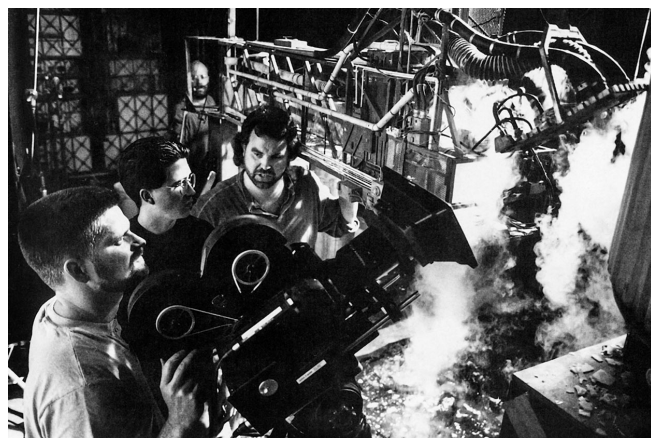
Apollo 13 had the perhaps dubious honor of being the first film ever to shoot aboard the KC-135. Using NASA’s own weightlessness simulator as a means to get their shots had, at first, seemed a far-fetched notion to Howard and Hallowell. “Ron was sitting around with Steven Spielberg, talking about how you could create a realistic zero-gravity effect,” Hallowell recalled. “They were throwing around all kinds of ideas, including filming underwater. Later, Ron turned to me and said, ‘You think there’s any chance NASA would let us film on the KC-135?’ I didn’t think so, but we checked into it; and after a few months sorting through the various levels of bureaucracy at NASA, they finally agreed to it.”

Backdrops which served as the command module and lunar module interiors within the KC-135 were created by Kansas Cosmosphere, a company that builds museum-quality space memorabilia for public displays. “We had them build a set that consisted of the lunar module, command module and a connecting tunnel,” explained Hallowell. “Then we hand-picked a camera crew of tough-as-nails guys who would be up to the physical strain. We had to accomplish as much as we could in the twenty-two seconds we had before the plane bottomed out on each parabola.”

Under the supervision of Howard, Hallowell and KC-135 director of photography David Nowell, the crew and the principal actors toughed it out for a month aboard the simulator, enduring thirty stomach-churning drops per each three-and-a-half-hour flight. “The KC-135 shoot would not have been possible if we hadn’t been blessed with three actors – Tom Hanks, Kevin Bacon and Bill Paxton – who believed in the story and were relentless in their enthusiasm for doing something that hadn’t been done before,” commented Hallowell. “In the end, we were averaging ten camera setups per



Motion control tracking movements down the side of the rocket were facilitated by positioning the model – together with its gantry – in a horizontal configuration on one of the Digital Domain effects stages.



To heighten the dramatic impact of the launch sequence, Howard and Legato determined to shoot the sequence of events from never-before-seen camera angles. Visual effects director of photography Erik Mash, with camera assistant Mike Bergstrom and modelmaker Jerry McClung, prepares for a closeup of the gantry arms retracting just before lift-off.

flight, which is every bit as good as you'd accomplish on stage. It was a very cost-effective solution for what would otherwise have been a horribly difficult process."

Although the KC-135 setup proved to be a relatively expedient means by which to realize authentic weightless conditions, a small number of zero-gravity shots in the film were achieved through the more traditional approach of suspending actors on wires. The image of the astronauts being pulled through the blown-out hatch in Marilyn Lovell's nightmare was one such shot. "This was one of the few cases where we opted to use wires," explained Matt Sweeney, who was charged with rigging the scene, "because wires were better suited to pulling the astronauts out of the spaceship. It took a new mindset to plan out these effects. We had to give the appearance that there was no up or down; but we also had to contend with gravity while creating that illusion."

The most difficult aspect of the assignment was achieving, through the use of practical rigs, weightlessness effects that were every bit as convincing as those filmed on the simulator. "When they first started shooting in the KC-135, I sent a couple of my guys to go with them," Sweeney recalled. "They came back with a videotape; and when I viewed it, I was horrified because what I was seeing was real weightlessness. The actors were doing double-axis somersaults; and it appeared slow and graceful, just like the NASA footage. My guys and I just looked at each other, and said, 'Boy, do we have our work cut out trying to match this.'"

"Matt's footage had to be consistent with the footage we were getting on the KC-135," Hallowell agreed. "His team had to match an incredible number of details, such as the way the straps on the suits behaved, the way the suits themselves puffed out in zero-gravity. They also had to puppeteer all of the floating objects in the scene so that continuity would match from shot to shot. Matt's guys were tireless, and they were passionate about making everything match up – which was crucial from a continuity standpoint."

After testing, Sweeney determined that a counterweight system using a parallelogram would work best for a majority of the shots. "It was kind of like a teeter-totter, with the actor on one end and weights on the other end. Since the actors were, in essence, weightless, they could bounce around, spin and generally act in a weightless manner. With wire work, people are typically strung from the hips; so they're restricted to movement around that axis. This system allowed movement along two axes because the attachment was fitted with ball bearings to let it spin freely; and the crane itself was mounted on a turntable. The system had enormous flexibility because we custom-built a range of attachments to support the specific positions and movement we needed to create for each shot. Also, Dean Cundey had his camera on a crane with a remote head that he could rotate at different angles; so in any given scene, the actors could appear as if they were upside down, right side up, on their sides, or any combination of the above."

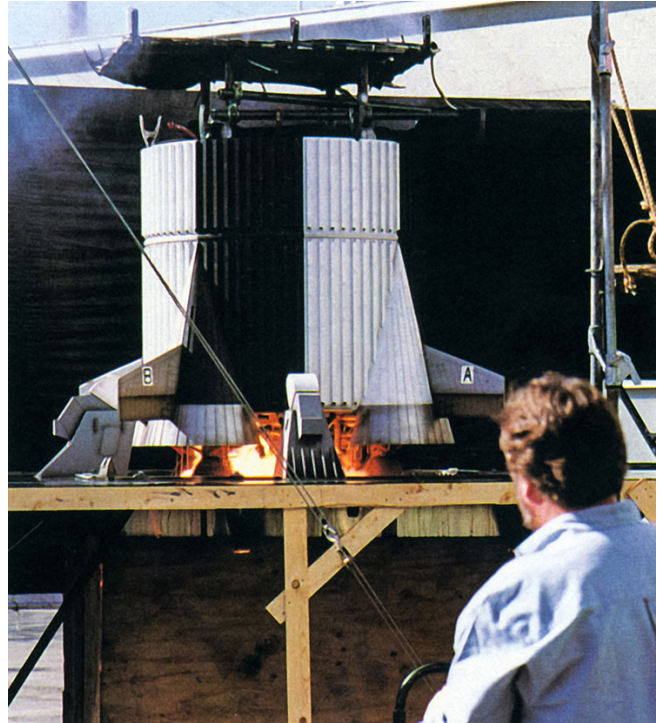
Supervising the rigging of each shot was set operations foreman Bobby Stoker, supported by Gary Zink, Steve Luport and Lucinda Strub.

With the principal actors, Sweeney and his team staged their tightly choreographed weightlessness scenes in and around a full-size mockup of the spacecraft, less than fifteen feet in diameter, constructed by Space Works. "The set piece was almost an exact replica of an actual command module," Sweeney said. "It was amazing to me to see how small those things were. It really made me understand the bravery of those astronauts. They basically went to the moon in a Volkswagen

bug!" A series of rehearsals within the mockup not only helped the practical effects team to determine what kind of rigging would work best for each shot, they also gave the actors a chance to become proficient in performing various maneuvers. "We were lucky because we had a really great group of actors who took very naturally to this and worked hard to sell the effect. During rehearsals, we directly compared our stuff on the monitors to the NASA footage that was filmed in space, and we were happy to see that they looked very similar."

Actors were not the only objects Sweeney was required to fly. The scene also called for everything from books to pencils to be flown on a variety of rod and wire rigs. "We use better materials these days," Sweeney noted, "but this is an ancient motion picture art and the methods are pretty much the same as they were forty years ago. We custom-built a large number of puppeteering rods based on where the objects would be floating in space, and basically walked them through the scene in whatever way we had to. It took a lot of skill to make these things look as if they were floating, because in zero-gravity everything moves in a very smooth, straight line. Any curve or wobble would break the illusion." For the final shot of the astronauts being sucked through the spacecraft hole, the actors were pulled through the set piece on wires, while a combination of fans and air blowers were used to blow paper and debris past them. Concluding the dream sequence is a zoom-in on Marilyn Lovell's eye, filmed within a vertically oriented set built by the art department. Kathleen Quinlan was strapped into an upright bed so that the camera could dolly smoothly toward her eye along a horizontal track.

Concerns weighing heavily on Marilyn Lovell's mind are amplified as her husband leaves for Cape Canaveral days before his moon mission. For a scene of her watching from their Houston backyard as Lovell's plane passes overhead, a miniature jet was to have been shot at Digital Domain and composited into a live plate. But with the motion control photography schedule already overloaded, Kevin Mack was asked to render the craft as a computer generated image. "I knew that Viewpoint DataLabs had already built a wire-frame model of the exact plane," Mack related, "so I said I could do it." Mack obtained the digital model from Viewpoint and customized it using the Amazon 3D Paint program, adding color, detail and a clear canopy in addition to decals and other markings. "I used Prisms to render the plane with motion blur, and then used the particle system application in the program to animate a stream of particles from the tail of the jet which became its exhaust. I created a smoke shader for each particle in Prisms and set up factors, such as turbulence, that impacted their movement behind the plane. I also added a refractive quality that gradually lightened the particles based on their age; so they appear transparent and hotter near the engine, then become more solid and white, eventually fading toward transparency as we move further from their point of origin."

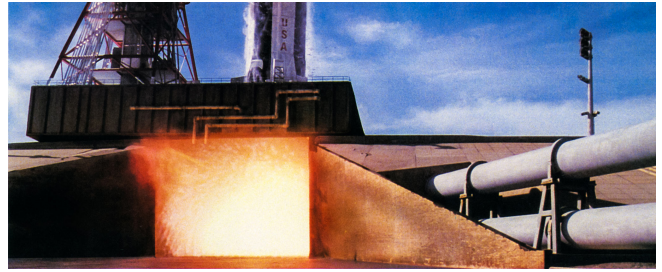


Pyrotechnic effects required for simulated rocket ignition were orchestrated by veteran pyrotechnician Joe Viskocil. Viskocil triggers an explosive charge on an eighth-scale section of the Saturn 5's first stage erected in the Digital Domain parking lot.



The initial blast is followed almost immediately by ignition of the main engines, resulting in a massive eruption of fire. Viskocil experimented with a wide range of explosive materials to replicate exactly the well-documented look of a real Saturn 5 launch.

Tracking the plane to the live-action proved to be one of the more difficult aspects of the shot. “I couldn’t use the treetops to track the shot because they were too close to camera,” Mack observed, “but there really wasn’t very much else in the shot to key off. I finally solved the problem by creating witness points on various clouds and tracking them through the scene. That allowed me to derive the camera move so it could be applied to the model jet at the appropriate distance.”



A wider shot of the ignition – incorporating pyrotechnics and fire extinguisher emissions – utilized a plate of the shuttle flame pit photographed at Cape Canaveral. As with other shots, the shuttle itself was painted out digitally and replaced with Saturn 5 model imagery. Sky enhancements, water reflections and interactive light were also created through digital matte paintings.

The movie then segues to Cape Canaveral, where the astronauts and mission control crew prepare for the launch. The pre-launch hustle is depicted in a scene in which the Saturn 5 is revealed being moved from the vehicle assembly building to the launch pad atop a squat, slow moving vehicle – fittingly dubbed the crawler. On location, a background plate containing the crawler was filmed from a helicopter, again using the stabilizing Wescam system. Model photography of the Saturn 5 had to be match-moved to the crawler in the plate. “We took the actual ‘X’s that were built on top of the crawler and lined those up with the same ‘X’s on a crawler wire-frame model,” explained Legato. “That allowed us to scale the camera move to fit the size of our model, and to put our miniature Saturn 5 rocket and gantry on top of the actual crawler.”

The rocket is revealed on its launch pad in a sweeping camera move that tracks down the side of the monolithic vehicle, taking in much of the countryside surrounding the launch site. The background for the shot was provided by two still photographs that had been taken on location. Originally, the stills featured the space shuttle, its booster tank and the skylab gantry. “One of our biggest jobs involved going in and digitally painting out the elements that we didn’t want,” stated Mack, “such as the shuttle, the shuttle gantry, telephone poles that were historically inaccurate and even birds.”

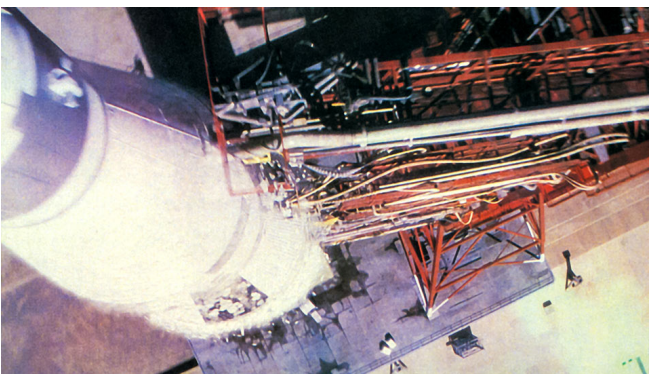
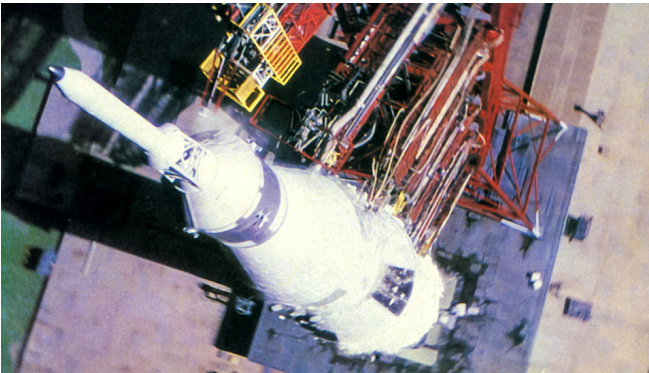
For the camera move down the side of the rocket, digital matte artist Martha Snow Mack created three separate maps by digitally combining the backgrounds that were shot in Florida. “I took elements from several photographs, painted out what I didn’t want and blended them all together to create a panoramic view,” said Snow Mack. “Then I added artistic touches such as a reflection from a distant lake and several layers of clouds to help give the rocket a feeling of size as you pan alongside it.” Between fifteen and twenty cloud paintings were generated, many of which involved repainting the entire sky. “It was a lot of work, so Kevin and I divided it between us. That worked out really well, because I like to paint wispy clouds and he likes the big, billowy type. Clouds are a lot of fun to do because they change all the time. Although the clouds were different every time there was a shot of the sky, we maintained a consistent look throughout the launch sequence. Candice Chinn took these maps and put them on a foreground plane, a middle distance plane and a background plane that she arranged in three-dimensional space. Then we used the motion control camera data to move through this 3-D environment; and when we felt we had it rendered correctly, Jammie Friday composited the model photography to the background using the Flame system.”

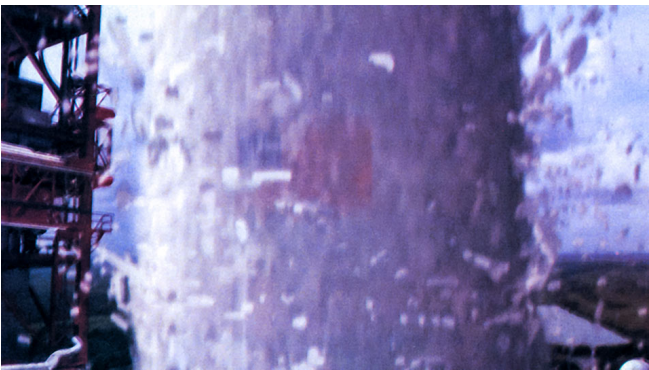
More digital touchup was needed for a shot of astronaut Ken Mattingly (Gary Sinise) watching the launch preparation from afar after being pulled from the mission at the last moment. “That shot was the grayest, most overcast, flat-lit thing imaginable when it came in our door,” said Kevin Mack. “Gary Walker did some amazing things to make it match the other shots of the launch preparation. He reworked the lighting in *Flame* to make it really bright and sunny; then I added new clouds and repainted the entire sky to match. He did a really nice skew on the clouds so that they could be seen moving behind the rocket. It all came together terrifically well.”

Also included in the pre-launch sequence were computer generated shots of condensation gas pouring down the side of the rocket as the camera traverses its length. CG was, in fact, the only viable option for creating the effect. “We had to film the model undercranked since the complexity and expansiveness of the camera moves precluded filming in real time,” said digital compositing supervisor Michael Kanfer. “Unfortunately, if a repeat pass of the camera move was used for a vapor pass, it would look unnatural because the vapor would be moving too fast. In addition, because of the motion control camera speed limitations, it was impractical to shoot real vapor. Doing it CG gave us infinite control over the speed and the look of the vapor, which changed its appearance during various phases of the launch. When the rocket is poised for launch, the vapor is pulled down by gravity; as the rocket gets moving faster and faster, the vapor looks different. Based on some early tests that Robert Small did with the vapor, we realized we would be able to create it digitally and that it would look great.”

To lock the computer generated gas with the rocket moving through frame, Judith Crow took a wire-frame replica of the Saturn 5 and matched it to data supplied from the motion control stage. The wire-frame model thus provided a digital guide for the particle system condensation gas. “The particle system was, in effect, locked to the wire-frame,” explained Kanfer, “so by aligning the wire-frame to the model shot, we were able to make the particle system gas tie in to the rocket.”

As preparation for the launch continues, the film cuts back and forth from the interior of the command capsule to mission control where computerized displays reveal the countdown. The electronic panels, boards and displays that are seen in the sets for *Apollo 13* were created by electronics foreman Arnie Peterson, working under the supervision of Matt Sweeney. “The production provided us with all of these authentic-looking instruments, some of which had actually been to the moon,” said Sweeney. “It was up to Arnie to take these museum parts and somehow make them work the way they were supposed to. He designed his own circuit boards and basically built his own computers from scratch to make everything work. We had to create forty-three separate control panels at mission control, and they all had to be interactive; so we bought wire by the mile, linked up dozens of monitors and installed more than five thousand mini-lightbulbs to create the look Ron was after.”





Activity increases as the countdown enters its final stages, culminating in a thundering launch sequence which is shown through a series of quick cuts taken from vantage points that could never have been found in stock footage. “The launch sequence is so deeply ingrained in people’s minds that we knew this was going to be the make-or-break point for the special effects,” commented Legato. “There is such overwhelming evidence of what the launch really looks like that we knew if we fell short with this sequence we would ruin the movie for a lot of people.”

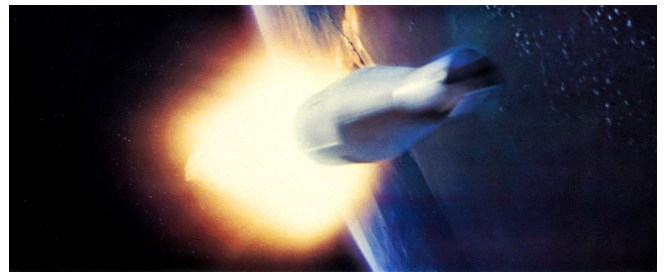
One way to distinguish their shots from the familiar stock footage was to show the launch from the astronauts’ point of view and other unusual angles, rather than from the common perspective of the ground-level spectators. “Nearly everything we’ve seen of Apollo launches was filmed with long lenses at 200 frames per second,” Legato noted, “which gives it a majestic, slow-motion appearance. The reality was much different. An Apollo launch was a frightening, rumbling sort of event. We tried to present that and capture the feeling of being right in the middle of the rocket as it takes off.”

In one shot, that feeling was captured by showing a view looking directly into the engine cones of the rocket miniature. “It’s sort of a God’s eye view,” said Ekker, “because you’d have to be inside the launch platform itself to look into the rocket from that angle. The sequence of events is that they first start the engines, which are monolithically huge. In reality, each engine is more than thirteen feet in diameter; and when the turbo-pumps are started, kerosene is expelled at over ten thousand pounds per square inch. Liquid oxygen is then expelled at the same rate to create a cloud of millions of cubic feet of extremely combustible materials – essentially a huge bomb that is waiting for a spark. That spark is provided with hypergolic igniters, two liquids that spontaneously combust on contact, and the resulting explosion lights the main engines.” Viewed from beneath the engine bells, the initial explosion is followed immediately by a larger blast as the main engines of the Saturn 5 ignite. Finally, the camera cuts to a view looking directly into the flame trench that channels the full force of the blast away from the rocket.

To create the spectacular pyrotechnics that would simulate this event, Rob Legato turned to pyro supervisor Joe Viskocil, who prepared for the task by studying as much NASA footage as possible. “You can take liberties when you are blowing up cars or spaceships or bridges,” Viskocil noted, “but I had to be absolutely accurate with this because everybody knows what an Apollo launch looks like. It was the biggest challenge of my career to make it look absolutely real. I did some testing with



After the launch, the spent first stage of the Saturn 5 is jettisoned, along with the metal ring that serves as structural reinforcement. The first stage and ring were shot motion control, separately, then composited against a NASA-supplied still photograph of earth which was digitally enhanced and bump-mapped onto a virtual sphere to create the illusion of three dimensions.



With the jettisoning of the second stage, the third stage engines are fired to propel the craft away from the earth's gravitational pull. The glow of the rockets was created by photographing computer graphics elements directly off a computer monitor.

various combinations of chemicals and explosives to try and recreate the look that was needed for each shot. I started off using a lot of chemicals, black powder, smokeless powder and gasoline, but ended up using a broader variety of chemical mixtures and fuels for the various effects.”

Leslie Ekker supervised the creation of the fire trench model – twenty-four feet long and eight feet wide – which was built out of plywood and plasterboard. The model was painted black and set up in the parking lot at Digital Domain, with the camera draped in flame retardant cloth and protected by a lexan shield. Viskocil used a combination of CO₂ and propane mortars to effectively simulate the power of the enormous blast that propels the huge rocket into the air. “The fireball was so powerful that it shook the entire building every time it was set off,” laughed Ekker. “It even set off car alarms for miles. It consumed so much oxygen that it sucked the drywall right off the sides of the model and destroyed the stage uprights underneath with its pounding. It was spectacular!”

All of the elements for the shot were composited by Adam Stark using the Flame system. “It was a fun shot to do,” noted Stark. “Every option I could possibly want was filmed on stage, and that gave me a lot of great material to work with. When they filmed the models, for example, they shot an interactive light pass, as well as a smoke pass – using fire extinguishers – and a non-smoke pass. I could then use Flame to modulate the light on the model to reflect the fire beneath it and add in the percentage of smoke that I wanted.”

Camera shake contributed to the drama of the shot, and was achieved through a system developed by digital effects supervisor Mark Lasoff and digital artist Simon O’Connor. “Simon came up with a high-frequency curve that he could adjust to change the amplitude and frequency of the shake that was added to each particular shot,” said Lasoff. “For the launch sequence, we wanted a very fast, low shake that looked like a powerful vibration. We used the same system for the reentry sequence at the end of the film, creating a higher, bouncier shake that gave the action a wilder feeling.” To simulate camera blurring that would realistically occur in photographing such a blast, O’Connor divided each frame of film into units which were smaller than 1/24th of a second and introduced up to four rapid movements per frame.

After the rocket engines ignite, the gantry arms are retracted just moments before liftoff. “We duplicated that in our miniature through a small motor that pulled a cable attached to the gantry arms,” Ekker explained. “We didn’t have to worry about hiding the cables on our miniature, because where we had them is where they are in real life.”

On the launch pad, up to four inches of ice can form on the Saturn 5 simply from moisture in the warm Florida air condensing and being frozen by the refrigerated propellants inside the fuel tanks. As the rocket lifts off, the ice breaks free and drops toward the ground, colliding against the arms of the gantry as they swing away from the projectile. To simulate this, Ekker created an eighth-scale model of the arm and practical ice chips made from a combination of paraffin and stearic acid. The interaction between ice and gantry was accomplished simply by pouring



An abundance of research material was gathered by the Digital Domain model crew to ensure the accuracy of all

the chips onto the arm from above. A more complex task was creating an interaction between the model and the condensation gas that matched what Robert Small had created digitally for other scenes. “We built a sheet metal plate that circled the model,” Ekker said, “and used liquid nitrogen to refrigerate this and create a laminar flow of convectional cold air down the face of the rocket. Then we would add a little carbon dioxide and get a nice flow as the vapor moved down the side of the model.”

miniatures constructed for the production. Model shop supervisor Pat McGluna, crew members John Ferarri and Kevin McLaughlin, and model crew chief Leslie Ekker check the detailing on their quarter-scale command module against photographic reference.

Although practical effects were employed throughout the sequence, some of the most striking images were attained using computer generated ice that was the brainchild of supervising digital artist Dennis M. Blakey. “I created a cylinder in Prisms,” Blakey said, “wrapped that around the surface of the rocket, and then cracked the cylinder into five thousand pieces to create the shapes I wanted. Each of those pieces is a single-surface transparent polygon, so it can conform to the surface without blocking our view of it from there it was kind of like setting up fireworks and timing the fuses to go off where I wanted. Each polygon was placed in a patch with the polygons around it, and each patch was given a time when it would start activating; so as the camera moves down, we see the ice crack off and fall in front of our eyes.” To create the interaction between the falling ice and the gantry, Blakey added 3-D boxes that represented the arms of the gantry as collision objects which would split selected polygons upon impact.

Prisms also played a role in the scenes that depict the bright plume of fiery exhaust as the Saturn 5 is launched. “David Isyomin worked out the initial look of the exhaust, using two elongated ellipsoids and two shaders he wrote in RenderMan,” explained digital effects supervisor Karen Goulekas. “The shader can be used to make shapes or particles look like smoke, fire, water, plastic or whatever. In this instance, David wrote shaders to define two different looks for the exhaust plume, and add noise and animation that would change these very simple pieces of geometry into some really incredible effects. He created an inner shader that consisted of very fast-moving streaky lines to create a sensation of motion – as if there are streams of hot gas coming down – and an outer shader that looked like yellow-orange fire surrounding the hot core.”

To create a glow that would help suggest the intensity of the exhaust, the computer generated effects were rephotographed directly off a computer monitor by Chris Dawson. When Mark Forker recombined that imagery with the original computer graphics element during compositing, a photorealistic glow was achieved. “To recreate that look using a CG element alone would have involved a longer production cycle,” commented Mike Kanfer, “and no matter how much you worked with it, there would always be something about the effect that would look a little too clean and synthetic. To create a grittier, more organic look, Chris aligned a Mitchell camera to a grid and photographed the computer monitor frame by frame. This allowed us to experiment with the exposure until we had the look we were after.”

Clouds that the rocket flies through on its ascent were painted in layers by Kevin and Martha Mack. In compositing, Adam Stark used mattes to place these clouds behind and in front of the rocket, creating an ‘Apollo sandwich’ that was made more convincing with the addition of interactive light. Stark then added motion blur, computer generated venting gas created by Kevin Mack and

simulated film grain to ensure that the digital effects would match up with the footage around them.

While working on the shot, Stark was advised by consultant Dave Scott that the fire from the exhaust slowly creeps up the back of the rocket as it leaves the atmosphere. To recreate this effect, Stark modified an existing fire element and laid it over the top of a black element. Using the Flame system, he then tracked the new elements to the base of the rocket, gradually moving them up to suggest that the flames were spreading.

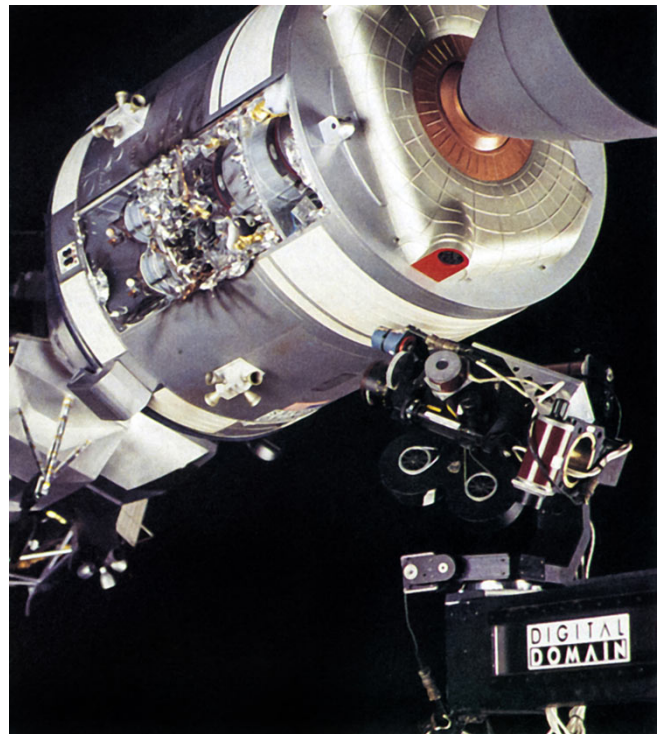
As the rocket gains altitude, the exhaust plume undergoes a gradual change, transitioning from a very intense downward blast to something with greater spread and animation. This change – based upon NASA stock footage – was achieved by Dennis Blakey, who used particle systems animation to give the exhaust a wilder, less contained appearance as it reaches the upper atmosphere.

One of Apollo 13's most dramatic effects occurs when the first stage of the Saturn 5 rocket is jettisoned in orbit, along with the metal ring that serves as structural reinforcement. The camera point of view is from inside the rocket as explosive bolts are fired to split the first and second stages apart. As the first stage falls away, a breathtaking view of earth is revealed, framed momentarily by the ring as it drops toward the surface. "There was a stock shot of the ring falling away to earth, and we wanted to create something similar," Rob Legato explained. "The original was a stunning image, even though the photographic quality was not very good. It was originally shot with a 16mm camera; and at this point, we were dealing with an image that was a number of generations away from that original. I wanted to create a higher quality image that captured the same feeling."

To achieve the effect, miniatures of the first stage, second stage and the ring were filmed separately with motion control, then digitally composited with a number of different elements, including sparks created practically by Joe Viskocil, computer generated debris and a striking digital matte painting of the earth. This earth – along with most of the other shots of the earth and moon in Apollo 13 – was created by digitally painting over NASA photographs to remove grain. "Mark Lasoff and Dave Scott went out to Jet Propulsion Laboratory and brought back hundreds of large prints of the moon," recalled Kevin Mack. "Mike Kanfer also got just about every photograph NASA had of the earth, including some really incredible views. The shuttle photographs had fairly good resolution, but they didn't suit our purposes for the wider shots since they were all photographed from a distance of only 150 miles above the earth. The photographs that provided the right perspectives for our wide shots were a handful of stills from the early Apollo missions. Both cameras and film stock have come a long way since 1969, so we had to repaint them to remove the grain and make them look as beautiful as we could. The closer shuttle source shots also had to be repainted. Some of these images were so large that Martha and I divided them up into four sections, just to make the repainting job more manageable."



Once in space, the Saturn 5 third stage splits apart so that the command and service modules can be docked to the lunar excursion module. Modelmakers Brad Plows and George Stevens prepare the LEM for a shot.



A motion control camera records the spacecraft in one of many scenes depicting its passage to the moon and back.

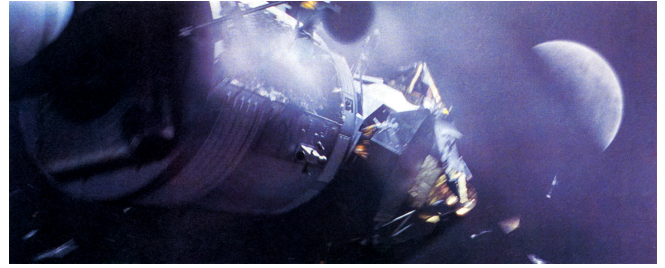
More than two weeks were spent removing grain and adding detail to the NASA photographs. The result was a view of earth from space which had never been shown to audiences with such clarity. To enhance the image, Adam Stark added a subtle glow, suggesting the light reflecting off the surface and giving the planet an ethereal beauty. "Both Jim Lovell and Dave Scott said that you can't imagine how beautiful earth looks from space," Mack noted. "They said it was spectacularly blue, like none of us has ever seen it before. That was something that we worked very hard to reproduce in all our shots of the earth."

Lunar photographs were also retouched, but not to the extent of the earth photographs. "For some shots, we did have to go in and repaint everything you could see of the moon," said Martha Mack, "but in others, we just had to extend existing photographs to fit into the frame, or add fine detail that helped create the look we were after."

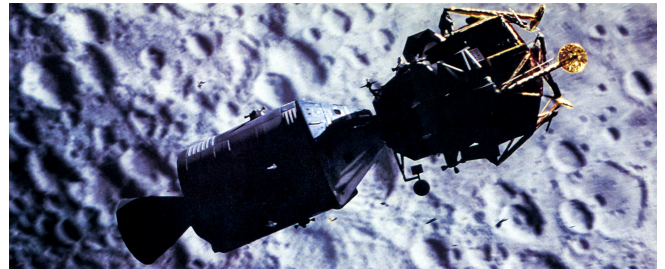
After the first and second stages are jettisoned, the third stage splits apart so that the command service module and the lunar excursion module can be reconfigured for the final push to the moon. Dubbed the 'lunar ballet' by effects team members, the sequence begins when four panels are blown off to expose the lunar lander which free-floats in space until linked to the command module via a docking maneuver. The panels were modeled in Prisms and painted in Amazon 3D Paint by Martha and Kevin Mack. Aaron Pfau modeled additional detail down to each individual rivet, then used Prisms to match the panels to the motion control photography of the miniatures and animate them as they spin away from the ship.

As was the case with the first-stage separation, the lunar ballet takes place against a vivid and dramatic backdrop – stars that shine with a brilliant clarity never seen within the earth's atmosphere. Ron Howard challenged Digital Domain to depict authentic starfields rather than the generic fabrications commonly found in space movies.

John McLaughlin answered the challenge by procuring a NASA database that provided digital reference data on more than ten thousand stars. He then wrote a program that allowed him to load the motion control data from the model photography directly into that database so that he could match actual stars and constellations directly to the action that was filmed on stage. "Ten thousand stars sounds like a lot," McLaughlin observed, "but we needed more. So we filled out the universe with random stars that we placed according to actual star distributions. We rendered the stars as spheres with a RenderMan shader, and Mark Lasoff ran more than a hundred exposure wedges to



After the explosion, the spacecraft tumbles wildly out of control as life-critical oxygen escapes from the damaged service module. The venting gas was created using particle systems animation. Computer generated shadow effects and flying mylar debris further enhanced the shots.



The astronauts continue on in the crippled spacecraft, intent upon making a single pass around the moon and then executing a free-return trajectory back to earth. Shots of the lunar surface were achieved by digitally enhancing NASA photographs.

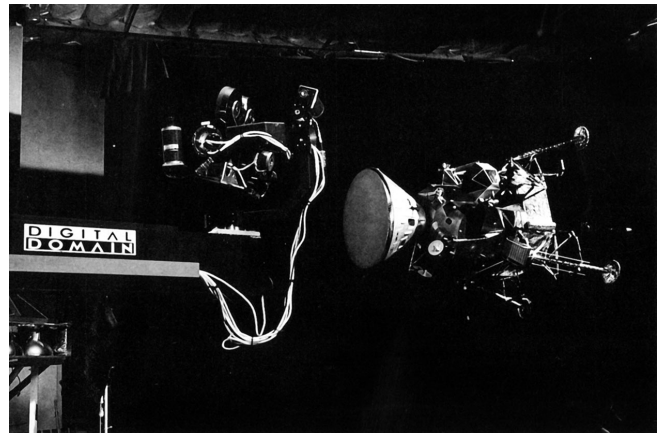
make sure we established the right brightness. Then we automated the process so that we only had to type in a few commands to create the stars for a particular shot.”

The docking of the command module with the lunar module was filmed in miniature. The quarter-scale LEM had been one of the most difficult models to construct, due in part to the complex arrangement of its spindly legs. “Dave Beasley, who is one of the finest craftsmen in the industry, did a terrific job of fabricating the landing gear of the lunar module,” Ekker noted. “The geometry is very odd, because the pieces flip over and lock into a shock-absorbing structure that just doesn’t seem to make sense when you first look at it. The legs are tipped with these strangely shaped cones and weird looking pieces that all lock together. For continuity purposes, we had to be able to quickly deploy and fold up the legs between shots. In reality, however, once the legs are deployed for landing they are never folded up again, because it’s a one-way trip for the lunar module. Of course, on *Apollo 13* that did not turn out to be the case.” Compositing of all the lunar ballet elements was accomplished by Gray Marshall.

In NASA parlance, the service module, command module and lunar module are known as the ‘full stack’ – and once established, this was the primary spacecraft configuration until reentry. The full stack was created by combining the three quarter-scale models into one eighteen-foot-long miniature, which posed particular difficulties for Erik Nash because of its size and the reflective surfaces on the outside of the command module. “It was basically a mirrored surface,” said Nash. “So we had to shoot the fill and the key passes separately. If you were to see the fill source reflected in the mirror, it would be a dead giveaway that it was shot in the studio. The technique we devised for our fill passes was to wrap the command module in black velvet so that you couldn’t see the fill source reflected, and then shoot the key pass separately so that there was only one reflection representing the sun. Usually, we would combine these two passes in-camera to save scanning time.” The reflectivity and size of the command module model also complicated the task of generating a clean matte. Up to five passes were often needed just to generate the matte outline, with another five passes required to fill in the holes created by reflections. Specific flyby shots also allowed the camera to see the astronauts inside the capsule, views that were



*At the motion control console on stage at Digital Domain, Erik Mash and his crew prepare for a shot of the linked command and service modules docking with the lunar excursion module in advance of *Apollo 13*’s final push to the moon. The resulting ‘full stack’ configuration was created by combining the three quarter-scale models into one eighteen-foot-long miniature.*



With the successful implementation of the return trajectory, the astronauts prepare for reentry into the earth’s atmosphere by jettisoning both the damaged service module and the lunar module. The free-floating LEM is photographed on the motion control stage.

accomplished by photographing stunt people against greenscreen and digitally compositing them into the shots.

One of the more unusual views of the command module showed urine being ejected into space after one of the astronauts relieves himself. Laura di Biagio employed particle systems animation to create a spray of crystallized liquid that was matched to motion control photography of the quarter-scale model. The shot was digitally composited by Mark Forker.

Television viewers are spared these less dignified aspects of space travel when the astronauts broadcast live from space – a broadcast which, as it turns out, none of the major networks deems worthy of running. Unaware that their images are being transmitted only to mission control the astronauts send greetings to America and conduct a tour of their spacecraft. To place images of Hanks, Paxton and Bacon on the many monitors and screens within the mission control set, viewing surfaces were replaced with bluescreens, allowing hold-out mattes to be created to retain the images of mission control actors standing or walking in front of them.

Realistic interference effects – suggesting the immense distance from which the images are being transmitted – were also created at Digital Domain. Footage filmed within the Apollo mockup was played through a 1972 vintage Sony television set and then rephotographed. The amount of interference was changed simply by varying the signal into the television set, allowing Legato to create very natural-looking glitching and squeezing of the image.

Transmissions between the command module and mission control suddenly deviate from routine when the service module oxygen tank explodes, blowing a hole in the side of the spacecraft. To recreate the explosion that wrought such havoc upon the real-life mission, Ekker and his team built a four-fifths-scale section of the service module – ten feet long – from a large piece of sheet metal that was rolled to the correct diameter and fixed to plywood bulkheads. The model was then cut laterally into two sections, with reinforcement added to the sections that would be stationary in the shots. Gordon Forkert designed a pneumatic ram that used a lever action and a flow rate controller to push against the center of the plate, making it buckle outward and split the seam with an unzipping motion that would be accompanied by a hail of computer generated rivets flying toward camera. “It had to rip along its length instead of just popping out in one location,” Ekker said. “The rig was suspended upside down on the motion control stage, and Gordon and I sat inside it while we operated the ram. We used two large carbon dioxide fire extinguishers to add frost to the metal and create the gas that escapes into space.”

The panel that was blown into space by the force of the blast was recreated in a miniature that Ekker based upon NASA accident reports on the mission. “It was basically just a piece of aluminum sheet metal that Brian Ripley and Mike Possert hammered, dented, bent rivets on, tore holes in, burned and generally took out their frustrations on,” Ekker explained. “We added mylar remnants, paint and decals, then filmed it within a ‘goal post’ rig that supported the piece while allowing movement along two axes to give it a tumbling, zero-gravity look.” Wider shots showing the damaged service module were created using the quarter-scale miniature of the full stack, which was redressed to match the damaged closeup section.

Most of the shots in the explosion sequence were comprised of twenty or more separate elements, including computer generated stars, earth or moon images and up to ten passes of motion control

photography, just on the spacecraft itself. “On top of that,” Goulekas said, “we also had a greenscreen pass to put the actors behind the windows of the command module. Then there were two layers of mist that John McLaughlin created, which were added as a foreground and background element – a venting gas effect produced using particle systems animation, and the mylar debris which was also computer generated. Finally there were two or three stage elements, depending on the shot, including liquid nitrogen, smoke and a number of explosion elements created by Joe Viskocil using smokeless powders and chemicals. Those were digitally combined and then rephotographed from the monitor to add a very organic glow to the finished explosion.”

Mylar debris that surrounds the spaceship after the explosion was created by supervising digital artist Neville Spiteri. To animate thousands of individual pieces of computer generated mylar, Spiteri adapted the program devised by Dennis Blakey for the cracking ice featured in the launch sequence, splitting a large surface that matched the dimensions of the sheet of mylar blown apart by the actual *Apollo 13* explosion. “We started with a polygonal mesh and then assigned points on the surface that were joined to produce the pieces it would separate into,” explained Spiteri. “To create more interesting shapes, we also assigned a large number of random points. Each shape was recognized as a single particle by the computer, so I was able to use particle systems animation and the program written by Dennis to animate up to a thousand pieces of mylar in each shot.” Using Blakey’s program, Spiteri defined the force and direction of the blast that would shatter the polygonal mesh. He then wrote a shader to make the surfaces of the polygons shiny and reflective so that each would accurately reflect the digital light sources imitating the sun and the light from the explosion.

In the aftermath of the explosion, the astronauts fire the spacecraft’s maneuvering thrusters in an effort to regain control. To assist Erik Nash in choreographing the complex motion control shots that would make the spacecraft appear as if it were tumbling wildly through space, the Digital Domain machine shop crew built an eighteen-inch encoder that had the same characteristics as the model and which could be spun by hand through all three axes to generate three separate motion control move files. “The idea was to program, in real time, the camera moves that would create this organic, out-of-control wobbling through an encoder that was wired directly into our Kuper motion control software so the shot could be filmed at a slower frame rate using the big model,” said Nash. “We used the hand-encoded moves as a jumping-off point, which we then had to edit to make the ship behave according to the laws of physics. It helped us visualize camera moves without having to get a ladder and go over to the model.”

The illusion of the vessel tumbling out of control was enhanced with live-action footage shot on the full-size mockup of the command module. The module was suspended on a motion control gimbal mount that allowed it to revolve around three axes. Dean Cundey used Cyberlights – a programmable light source developed by Lightwave Research – to simulate the lighting transitions that reflect the position of the portholes relative to the rising and setting of the sun and moon. “When the ship was



Shots of the lunar excursion module’s separation from the command module were set against a dramatic background of computer generated stars. Instead of rendering random star patterns, typically featured in space films, the digital team used NASA databases to

moving normally, we were able to create the effect using a single Cyberlight mounted on a Chapman crane,” explained Jeff Hand of Towards 2K, the company that provided the Cyberlights and implemented their use, “but for scenes where it is tumbling, we placed a Cyberlight along each axis of motion to reduce the setup time. When the porthole was supposed to be facing the sun, we went with a very stark white light; but when it turned toward the moon, we used a filter to create a different shade in the cabin. With a minimal amount of programming, the crew could create this transition whenever they needed to, and suggest very definite motion through a stationary lighting rig.”

accurately recreate actual stellar configurations. Separate elements were critical to the reentry sequence. After conducting a series of tests, Rob Legato and Joe Viskochil were also composited into the shots devised a technique for the fiery reentry that entailed shooting an intense propane burn at two seconds per frame. To prevent the model from being consumed in the prolonged exposure, a fireproof capsule was made entirely of steel and drilled with hundreds of holes for the passage of propane. Camera shake was added in the digital compositing phase to heighten the out-of-control quality of the climactic scene.

As the astronauts gain a semblance of control on the wobbling spacecraft, computer generated gas and debris are seen trailing behind. Without much recourse, the imperiled astronauts continue to navigate toward the moon in their crippled module, hoping they can use the lunar gravity to loop around the orb and return to earth before their remaining oxygen and power supplies are depleted. In the midst of this drama, Jim Lovell has a vision of what might have been, a daydream in which he steps triumphantly onto the lunar surface and obtains a perspective of the moon – and earth – seen by only a handful of human beings. To suggest the reduced gravity of the moon, Tom Hanks was flown on wires from a construction crane as he hopped off the ladder of the lunar lander – a full-scale replica fabricated by Wonderworks – onto a lunar landscape set constructed outdoors at Universal by production designer Michael Corenblith.

To obtain a better view of his spectacular surroundings, Lovell opens the sun visor of his helmet, revealing the faceplate which shows his features, along with a striking reflection of a distant mountain that extends upward from the lunar surface. When originally filmed, the mirror-like surface of the helmet displayed little of the set, but a great deal of the crew who were positioned behind the camera. To create a more fitting reflection, digital artist Caleb Howard used Prisms to model a lunar landscape. “We initially tried adding detail through procedural texture-mapping,” stated Mack. “This had the general look we were after; but when you saw it close up, it was very crude. So Martha used Amazon 3D Paint to add the additional detail that resulted in a crisp image. This was laid over the three-dimensional geometry and ray-traced onto a 3-D model of the faceplate that Caleb created from measurements taken on the set. The reflection, and the distortion of Tom Hanks’ face due to the curved surface of the faceplate, was very straightforward because the math that defined these things was built directly into Prisms.”

Next is a view of the lunar surface, with the earth in the background. Kevin Mack scanned in a NASA photograph to establish the moon surface, then added painted detail and layering elements in a multiplane configuration that helped create an effective illusion of movement and perspective shift. “The NASA photograph had a rock in the foreground that was easy to identify,” Mack said, “so I cut that out, painted over the area where it had been, and mapped the rock onto a polygon to create my foreground layer. I set up most of the original photograph as my second layer, except for the distant landscape that I cut out and established as a third layer. Behind that, I added the earth and John McLaughlin’s computer generated stars as a fourth layer. Using Prisms, I placed each of these

layers at varying distances from my digital camera, and then added a slight camera move so that we had movement in three-dimensional space, rather than a static image. The method is pretty similar to traditional multiplaning, except that it's virtual multiplaning – there are no physical paintings, and the 3-D space really only exists in the computer.”

As *Apollo 13* circles the moon, it passes around the dark side and then emerges back in sunlight as it completes the arc. The effect of the sun appearing on the horizon was achieved through a combination of motion control photography and digital manipulation. Although a computer generated moon would be composited into the final shot, a four-foot-diameter moon model was placed in front of a 10K light that was used to represent the sun to create the appropriate interactive play of light and shadow. To make the effect appear more believable, digital lens flares were created in *Alias* by Randall Rosa and positioned to suggest that the event was photographed by an actual camera.

Emerging from behind the moon, the capsule enters a free-return trajectory and the astronauts are on their way home at last. Still ahead, however, is the risky reentry into the earth's atmosphere which will severely test the limits of the command module's possibly damaged heat shield. The reentry sequence was brought to life with a stunning combination of miniatures, motion control photography, pyrotechnics and computer generated elements, with digital compositing ensuring a seamless blend between the disparate elements.

Because of its fiery nature, much of the reentry sequence required flame elements executed by Joe Viskocil. “I looked over past films to see what had been done for reentry scenes,” said Viskocil, “and all of them looked phony to me, including *The Right Stuff*, which used liquid nitrogen to substitute for flames. I did some tests and suggested that we use an undercranked camera to film a very intense propane burn. We ended up photographing it at two seconds per frame, and I had to bring the flame up very slowly to create a controlled effect. The model could be in the middle of this extremely hot flame for up to sixteen minutes per take.”



Dire predictions that the damaged vessel would be unable to withstand the intense heat of reentry are proved wrong as the craft successfully splashes down in the South Pacific. Shots of the event were achieved by parachute-dropping a weighted quarter-scale capsule from a helicopter into the waters off Catalina Island.

To create an exact match between Viskocil's pyrotechnics and the model which was filmed motion control, a duplicate capsule was built out of fireproof epoxy. "After we emptied two fire extinguishers and still couldn't put it out, we had to rethink our definition of fireproof," remarked Ekker. "Each heat shield piece had fifteen hundred holes drilled in it for passage of propane, and then had fireproof cloth draped over that which was siliconed in place. Unfortunately, the cone shape focused the heat energy like a radar dish; so we went through four cones, four heat shield pieces and a couple of bulkheads before finally building a cone entirely out of steel."



Subsequent shots of the crew recovery utilized a full-scale replica of the heat-seared capsule built by Wonderworks.

For shots of the capsule at lower altitudes, where increased atmospheric friction would create an active glow from ionized particles, fans were used to increase the size and movement of the flames. "It looked just beautiful," Viskocil said, "because it was shot so slowly that it created this extremely fast motion, as if the capsule is screaming through space. It has an organic look that would have taken months to try and duplicate as a computer generated effect; and even then I doubt it would have been as effective as using propane, which was an extremely simple solution." Camera shake achieved in postproduction added to the out-of-control feeling of the reentry as the capsule descends to earth on a column of flame. Burning vapor and a fiery trail behind the capsule were added as CG elements – composited by Jammie Friday – along with background atmosphere streaking by. One wide shot of the burning capsule was entirely computer generated.

Redressing of the model – based upon NASA footage and photographs – was extensive and served to suggest the result of the intense heat to which the capsule was subjected. "Reentry basically fries every square inch of the module," stated Ekker, "so we repainted it a mixture of gold, black and red. We also removed some of the mylar and reduced sections of the heat shield to suggest that these have been burned away. We painted all of the protrusions and edges with red ultraviolet paint that would fluoresce under ultraviolet light; so the red-hot glow on these areas could be changed simply by varying the amount of ultraviolet on the model." Additional effects attempted during motion control photography included pumping liquid nitrogen down the sides of the model and blowing it back with a fan – although less than a second of this appears in the film because it did not appear as convincing as Viskocil's flame effects.

Dropping fast, despite the three parachutes deployed and trailing behind it, the capsule hits the ocean with tremendous impact, sending a column of spray rising into the air. The capsule momentarily disappears, then emerges from beneath the waves, bobbing like a cork. The spectacular conclusion to the reentry wild ride was filmed in the ocean off Catalina Island, some twenty miles west of Los Angeles.

For the parachute drop, the modelmaking team built three heavy-duty capsules that matched the redressed quarter-scale hero model. To design the actual parachutes, Ekker enlisted the help of Moe

Villette, who also did the parachute coordinating for *Terminal Velocity*. “Moe learned his skills through the exceptionally dangerous sport of base jumping,” said Ekker, “so he is extremely good at creating parachute effects that work every time. You can’t miniaturize the effects of aerodynamics, so we had to use a combination of physics, engineering and Moe’s expertise to determine how the chutes would be designed to appear as though they were in scale, but still be able to function effectively.”

After a number of inflation tests, it was decided to construct parachutes that were twenty-one feet in diameter. For the actual drop, those parachutes were attached to the capsule miniature, which was held in place by a steel framework clamped directly to the landing skids of a helicopter. The entire assembly was then released over the ocean. A test drop using all three parachutes and a miniature weighted with 170 pounds of bird shot was conducted, but the results proved inconclusive due to weather conditions. “We had so much fog at the drop zone that we could only run one test,” Ekker recalled. “From that we could tell that 170 pounds was too light – but we weren’t able to determine what the weight should be. We finally decided to weight the miniatures at three hundred pounds. It was just a guess, but it was a good one because the chutes deployed correctly over time.”

Organized by visual effects line producer Cari Thomas, the splashdown was filmed from five cameras, including a handheld unit operated by Erik Nash from the drop helicopter and a Wescam system from a second aircraft. “That was a lot of fun because it wasn’t motion control,” commented flash. “It was real live outdoor photography. I was standing on the skid of the helicopter shooting straight down as the capsule fell away and the chutes opened.”

Initially, the splashdown was filmed using a half-scale capsule miniature suspended beneath the miniature parachutes. “The model was dropped from one hundred fifty feet the first time,” noted Ekker. “At that height, the parachutes had too much time to slow it down, so the model just hit the water with a gentle splash.” The resulting footage was sufficiently disappointing that Rob Legato opted to reshoot the scene using the quarter-scale capsule dropped from a lower height of fifty feet. This time, the model hit the water hard, with the chutes deploying just moments before impact. “The capsule hit the water and a huge geyser of water shot up in the air. The impact was so great, the capsule sank to about six feet below the surface of the water before it popped up and bobbed – just like it was supposed to. It ended up working beautifully.”

The splashdown, like all of the effects sequences in *Apollo 13*, was so realistic that it looked as if it could have been taken from the NASA stock library – except that the dramatic camera angles employed would never have been possible in real life. “In *Apollo 13*, you feel as though you are seeing reality, but in a way that has never been presented before,” Todd Hallowell enthused. “There’s a familiarity to the style of the shots; but then, suddenly, the camera begins to move in ways that would never have been possible in reality. Everyone who worked on these effects put in a tremendous amount of extra effort to help Ron convey what it would have been like to be a physical part of the *Apollo 13* mission. It would have been far cheaper and faster to have simply done cleanup work on NASA’s footage – but I’m glad that we didn’t do that. With effects, we were able to come up with solutions that were far more cinematic than anything NASA could have provided.”

Early test screenings revealed that the effects were so convincing that many audience members believed they were seeing actual NASA photography. To dispel the notion, Hallowell wrote a memo to the publicity team at Universal explaining that no NASA footage was used in the film. It was the highest praise possible for the artisans at Digital Domain. "When our effects are so subtle that they're being mistaken for the real thing, that's a good indication that we've succeeded," Jenny Fulle noted. "Everyone worked particularly hard on this show because the subject matter made it very special. I've been doing this kind of work for a long time, but I've never been so proud of anything as I am of the work we did on *Apollo 13*."

Fulle's sentiments were echoed by Matt Sweeney, a hardened professional with many years of experience creating film effects. "Every so often a film comes along that you feel really proud to be a part of," Sweeney reflected, "and this was one of them. Everyone gave it that little bit extra because we knew that this was more than just entertainment. Not only was it an excellent film, it was also an accurate representation of one of this country's better moments."

There was, perhaps, no better testimonial to the effectiveness of *Apollo 13* than its impact on Rob Legato, the man who had been in on its making since it was nothing more than a set of rough storyboards. After seeing the completed film all the way through for the first time, Legato was approached by Ron Howard who solicited his reaction. "I knew the astronauts were going to get back alive,' I told him. 'I knew they were going to splash down safely. I shot the splashdown, so I knew exactly what was going to happen every second. Yet, I still got caught up in this story, and I still found myself holding my breath at the end. And if the movie can affect me that way, then you've created magic.'"

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FOREVER AND A KNIGHT

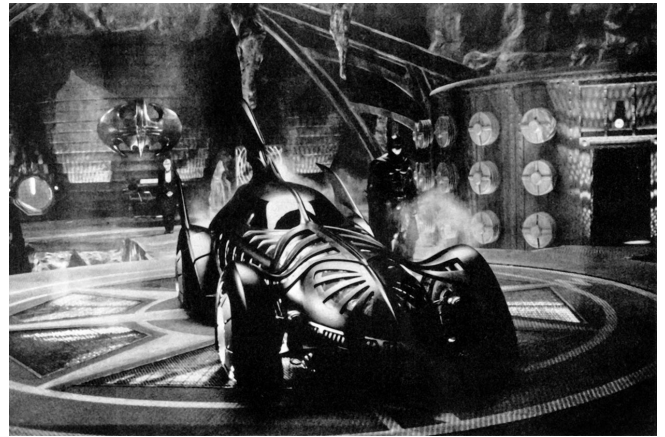
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article by
Mark Cotta Vaz

With its brooding *Batman*, psychotic *Joker* and gothic Gotham City, *Batman* – director Tim Burton’s phenomenally successful 1989 film – was a revelation, particularly for critics and moviegoers expecting a big-screen evocation of the campy sixties *Batman* TV show. >*Batman Returns*, Burton’s 1992 follow-up, was darker still, with Gotham Plaza rendered fascistic and dehumanizing, the Penguin portrayed as a sewer-dwelling mutant plotting to murder children, and Catwoman a leather-clad, whip-cracking wildcat ready to rumble for the anarchistic kick of it.

For Tim Burton, attracted to offbeat characters and a fan of the stark, dark style of German Expressionism, *Batman* had been a grand canvas. But although he had built the comic book concept into a franchise film property for Warner Brothers, ringing up more than \$400 million in domestic boxoffice returns, there was some grumbling, after the sequel’s release, from parents unhappy about the unseemliness of infanticide and McDonald’s Happy Meal promotional tie-ins. Rumors were also rife that Burton had tired of the series.

Batman Forever, the studio’s current big-ticket production, would see wholesale revisions in the *Batman* saga. Although Burton would still keep his hand in the project by serving as producer, together with Peter MacGregor-Scott, the directorial reins would be turned over to mainstream moviemaker Joel Schumacher. “I was born in 1939, the same year *Batman* was created,” Schumacher commented. “I’ve always loved comic books – they’re like storyboards for films – and I’ve always been a *Batman* fan. So when Warners approached me to do the film, the



In *Batman Forever* – Warner Brothers’ third installment in its comic book film franchise – the directorial reins were transferred from Tim Burton to Joel Schumacher, who brought a lighter touch to the proceedings. Significant changes included the casting of Val Kilmer – replacing Michael Keaton as the mysterious Caped Crusader – and the introduction of Robin to the series. Also introduced were a new batmobile and a redesigned batcave, erected in a giant Long Beach dome hangar that formerly housed the Spruce Goose.



Adding campy villainy to the production were Jim Carrey as the diabolical Riddler, a techno-nerd turned criminal mastermind, whose chief pleasure is derived from taunting victims with obscure riddles; and Tommy Lee Jones as Two-Face, former district attorney turned deranged crook, whose facial features are hideously acid-

adult in me might have pondered it, but the child in me said 'yes' immediately."

scarred on one side while perfectly normal on the other. Appliance makeup for the character was designed by Rick Baker.

The transfer of directorial responsibility from Burton to Schumacher was not the only major change the new film would bring. Actor Val Kilmer would replace Michael Keaton as the Dark Knight, Robin would finally be introduced into the series, and Gotham City would be redesigned and lit up with splashes of comic book color. Both the dark and cartoony forces of the mythos would be retained in the film's villains – Two-Face, the once crusading district attorney Harvey Dent, whose mind has become unhinged by the facial disfigurement caused by a splash of acid; and Edward Nygma, aka the Riddler, a mastermind given to posing puzzles that hold clues to his forthcoming criminal escapades.

In addition to an ambitious slate of traditional miniature effects, the production would also boast an abundance of computer generated illusions. The computer graphics and image processing capabilities currently revolutionizing the film business had been but a glimmer in the visual effects landscape when *Batman* was first released. Six short years later, the filmmakers behind *Batman Forever* would be creating computer generated Gotham cityscapes and even a computer generated Batman. It was a brave new world, and one with which Joel Schumacher was not entirely familiar. "I was vaguely aware of the tools," Schumacher admitted, "but I had to do some reading up on it. What I discovered is that you can do anything with this technology now." Helping Schumacher chart his course was visual effects supervisor John Dykstra. Dykstra had gravitated to the production not long after his groundbreaking Apogee effects company was dissolved in January 1993. The release of *Batman Forever* would mark the twentieth anniversary of his commencement on *Star Wars*, the film whose landmark effects he supervised and for which he was honored with an Academy Award. For one whose professional experience had revolved around motion control camera systems, optical printers and the world of photochemical and physical materials, the age of virtual cameras, image processing and computer generated characters meant new artistic freedoms. Advanced digital tools now at his disposal would allow Dykstra – and an army of effects practitioners – to bring wholly to life Schumacher's vision of a film fusing both live-action reality and the fantastic, graphic sensibility of the *Batman* comics.

"On this film, there's an interesting mix of realism and the forced perspectives and unusual colors of the comic book," Dykstra commented. "It's less theatrically staged than the first two films, more stylized and surrealistic. We were able to open up Batman's world because of the images we can now bring to the screen. All of the storytelling genres have been opened up, in fact; but the technological ability to produce those kinds of images feeds upon itself, so these types of pictures aim to top themselves in scale and complexity. As a consequence, the scope is so great that the collaboration needed to produce these images has never been a more important factor in a film's success than it is now."

On *Batman Forever*, the art of collaboration was particularly vital, given that the studio had allotted a mere three months for postproduction, a seemingly impossible schedule for a film with some 250 effects shots. "One of the biggest challenges the production faced was the postproduction schedule," Dykstra affirmed. "Basically, first unit and postproduction were occurring at the same time. I incorporated into my thinking how to complete an accelerated back-end, but I also tried not to let

the time period we had limit the envelope we decided to draw for ourselves in making the picture. We set out to do visual effects as they integrated into the story.”

More than eleven effects houses would be in on the action, with many shots requiring the efforts of three or more vendors with specific expertise: Warner Brothers Imaging Technology, gearing up to create a digital backlot for its parent company, would create some of the most complex CG cityscapes and digital matte paintings ever attempted in a feature; the character animation specialists at Pacific Data Images would have the task of creating a computer generated Batman for mega-stunt scenes; MetroLight Studios, well versed in digitally producing photorealistic representations of natural phenomena, would furnish a new-look bat signal; Rhythm & Hues would create part of the Riddler’s lair via computer graphics, and composite in bluescreen photography of *Batman*, Robin and love interest Chase Meridian; Illusion Arts would bring both traditional and digital tools to bear on key establishing scenes; the editorial suite at Composite Image Systems would be utilized to assemble some ninety-nine complex shots; Rick Baker’s Cinovation Studio would contribute animatronic bats and the Two-Face makeup; and VIFX would take to their own water tank and an Olympic-size swimming pool to realize underwater explosions and a pivotal batwing transformation.

To coordinate the massive project, specific supervisory duties were assigned to team members under Dykstra’s direction, with Boyd Shermis and Eric Durst dividing the miniature photography between them, David Stump serving as effects director of photography with the first unit, and Andrew Adamson taking charge of the digital workload. “With all of these vendors,” Adamson commented, “the challenge was making sure everything had continuity. In a way, the short deadline was a good thing in that it forced us to make quicker decisions, which meant going with John Dykstra’s instincts throughout the movie. John pushed some things in digital that people haven’t tried to do before – or have tried unsuccessfully – such as creating a number of CG environments and doing a CG stuntman for some of *Batman*’s action scenes. The short deadline resulted in a very aggressive approach to the movie.”

One of the ways in which Dykstra sought to insure continuity-essential with so many companies doing digital effects and compositing – was to engage a single source to provide high-resolution film scanning and recording services for all of the companies involved. After researching available options, he selected EFILM – short for Electron Filmworks – a digital film laboratory founded in 1993. “The idea,” Dykstra explained, “was to run the primary scanning and recording through one facility so that, in a single step, I could eliminate a whole raft of variables, including color, gamma curves, black levels and sharpness, and achieve a consistent look across as many effects houses as I need to work with.” Although circumstances prevented one-hundred-percent achievement of this objective, EFILM did provide most of the scanning and recording for the production – a total of some 97,000 frames of film.

From the start, Schumacher and his creative team were determined to not merely reflect Tim Burton’s unique vision, but to take the series into new and exciting creative areas. “My research included going to DC Comics and poring over hundreds of *Batman* comics from 1939 to now,” Schumacher recalled. “When you immerse yourself in hundreds of comics, you come away with an enormous respect for the artists, particularly for the way they used color. For this film, I wanted to make the comic book. I didn’t want to go so far as to use bordered panels, but I did want to frame

the movement in such a way that I could create a sense of the design and impact of a comic book panel. Because of computer technologies, we were able to enhance all the buildings with heightened colors to create the colorful look of a comic book.”

Tasked with bringing the comic book aesthetic to *Batman Forever* was production designer Barbara Ling, who had previously collaborated with Schumacher on *Falling Down*. One of her major assignments was to recreate and redefine Batman’s Gotham turf. The centerpieces of the first two films had been, respectively, a quarter-of-a-mile backlot Gotham City Square set at Pinewood Studios in England, and a Gotham Plaza set that filled the biggest stage at Warner Brothers. The Gotham of *Batman Forever* would not be as theatrically based, but would be created with motion control miniatures, computer generated cityscapes, matte painted vistas and some location work in New York and Los Angeles.

Preproduction for *Ling* included a four-day trip to Japan to look at cutting-edge modern architecture, and starkly contrasting visits to abandoned and boarded-up New York subway sites full of art deco and gothic elements. Also providing inspirations were the classic Machine Age designs of architect Raymond Loewy and the visionary drawings of a monumental, futuristic New York by architect Hugh Ferriss. But the ultimate creative resource was the *Batman* comic book tales which had developed a more complex and cosmopolitan Gotham than had been explored in either the TV show or the earlier films. That mythic Gotham was not merely a noir landscape of full moons, long shadows and lurking denizens of the underworld, but a cosmopolitan environment of high-rise buildings, fashionable shopping districts, skid rows, industrial centers, waterfronts and an exotic Chinatown. "My approach was to open up Gotham so you could get the sense of diversity you would find in a real city, with a mix of cultures and buildings that were both old and futuristic-looking," Ling explained. "I didn't want Gotham to be tagged to a specific time period. One of the great aspects of the *Batman* comics is that they're timeless."

The Gotham of the comics was also a surreal landscape of giant, rooftop advertising props and monumental statuary. The concept of massive sculpted figures integrated into the urban landscape would be one of the major *Batman Forever* design motifs. Although production designer Bo Welch had embellished *Batman Returns* with a smattering of such sculpture – in particular the muscular male figures ringing Gotham Plaza – the *Batman Forever* cityscapes would incorporate sculptures nearly as large as the buildings themselves. "When Barbara and I designed Gotham," Schumacher stated, "what was most important to me was that there be huge statues throughout the city. In some of my other films, I had had this sculptured look, such as the medical school in *Flatliners* in which the building's architecture is full of faces and forms that seem to



Expansive miniature sets, filmed motion control under the supervision of Boyd Shermis and Eric Durst were combined with computer generated imagery, matte paintings, full-scale set pieces and location footage to create a complex, cosmopolitan Gotham City. Modelmakers working under supervisor Michael Joyce constructed several large set pieces from scratch, as well as pressing into service a number of miniature skyscrapers originally built by Stetson Visual Services for The Hudsucker Proxy. The existing miniatures required

be holding everything up. It's amazing the emotions we invest in the human form. I thought that these statues would add a lot of personality to the city."

extensive restoration and detailing to accommodate the retrofit design motif of the film. A motion picture city model reveals the surprising Gotham City skyline, a trend that the cityscape incorporated into the cityscape of comic book color.

The final design for Gotham featured a vaulting, vertical motif – a trend in fantastic cities from Metropolis to *Blade Runner* – with the notion that retrofit architecture built atop older skyscrapers had extended the height of the city skyline. "The idea, developed from early conversations I had with Barbara, was that as the city grew upwards, existing buildings were retrofit and transformed into a newer layer of Gotham," explained James Hegedus, visual effects art director in charge of bringing the designs into the realm of computer graphics and miniature photography. "The city starts off with an older, deco feel, but the original forty- to fifty-story buildings have been retrofit into super-structures that are now eighty to ninety stories tall. It was also our intention that Gotham would possess many different areas – not only laterally across town, but vertically as well – so we incorporated layers of new bridges and super-roadways into these levels to accommodate traffic at the upper reaches."

Two major fly-through sequences would demonstrate the expansiveness of the city: a nighttime bank heist and helicopter flight achieved with models and miniatures, and a daylight passage through a completely synthetic Gotham. The former sequence, which opens the movie, was filmed on miniature sets erected at a former Hughes Aircraft hangar in Marina del Rey where army helicopters had once been produced. The facility, in sight of the double-size hangar in which the Spruce Goose had been built, was divided up into moveable shooting stages and had an adjoining airstrip for staging miniature pyrotechnics. The principal Gotham cityscape consisted of fourteen twenty-fourth-scale art deco skyscrapers built originally by Stetson Visual Services for *The Hudsucker Proxy*. The miniatures had an unusual pedigree, having gone from Warner Brothers after the completion of *Hudsucker* to Universal Studios for *The Shadow* and then back to Warners for the third *Batman* film. "When we started, the Hudsucker buildings were really decrepit," noted model shop supervisor Michael Joyce. "We had a ten-person crew spend about a month getting the buildings up to snuff, casting new molds for parts to replace windows, fire escapes or other missing parts."

Once restored, the miniatures – many approaching fifteen feet tall – were detailed with pipes and buttresses and monumental sculptures to accommodate the retrofit design scheme of *Batman Forever*. Joyce and his crew also built a number of buildings from scratch, including one under construction and two scale versions of the Second Bank of Gotham which would be the setting for the heist and the ensuing battle between Two-Face and *Batman*. "We built about seven stories of the Gotham Bank in sixth-scale, which gave us a model about twenty feet tall," Joyce explained. "We also built a twenty-fourth-scale view of the full bank which, at twenty-eight feet, was our tallest building. It took six weeks for Greg Stuhl and Dave Emery to build the twenty-fourth-scale Gotham Bank as a three-sided plexiglass miniature, with two ten-foot sections and an eight-foot section all bolted together. Our big bank had a lot of retrofits on the top half of the building, with flying buttresses, a clock, statues, pipes, green smoke-glass windows and marble fascia. There were a lot of details, such as seven hundred window sections for the sixth-scale building wall, all made separately of styrene. They were painted, glued on and scribed with a straight-edge scribing tool so

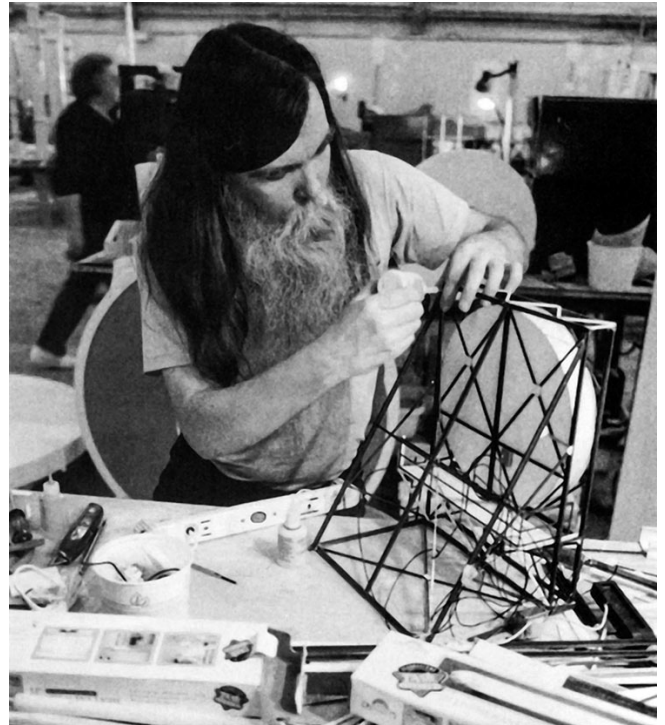
we could get caulk in there to look like grout. Scott Valdes, who headed up the paint department, hand-painted surfaces on both of the banks in scale to look like marble.”



A harbor statue of Lady Gotham was sculpted, photographed by itself and matted into the city scape as needed. Modelmaker Pete Gerard installs a rotating searchlight in the statue's torch.

The Hughes hangar work would include a complex shot combining New York location footage of a roaring batmobile with a camera tilt-up transitioning to a crowded miniatures skyline and a MetroLight bat signal above. The shot required three layers of bluescreen photography of the miniatures. Eric Durst – using motion control equipment and crews provided by The Chandler Group – employed three Personal Animation Recorder units to assist in lining up all of his complex composite shots. “What we did was different from digital previsualization because we were not creating 3-D CG images,” explained motion control camera operator Mark Hardin. “Rather, we were utilizing a video tap from the cameras, with each frame of information corresponding to a frame position in the motion control unit so we could play the shot back frame by frame and lay down test move after test move. For the bank heist sequence, we could take the motion control move of the flight through the city, play it back, and lay the helicopter move to correspond frame by frame with the flight path.”

“The PAR system was a lifesaver because there were many things to match and check out,” Durst affirmed. “We matched the live-action with an animatic we did in CGI, and then we matched our motion control miniature photography to the live-action – so there were two levels of photography on this shot for the rise through the city. All of the different elements had to fit perfectly, because if the buildings weren’t lined up right they would start to separate. PAR came out about two and a half years ago, but its capabilities for motion control have only been recently realized. Previously we would have to shoot tests on high-con, black-and-white film, then sandwich them on the Moviola. Now we can marry elements more interactively; so, basically, we can do four shots in the length of time it once took to do two. It’s still motion control model photography; but what’s new is that we can marry so many more elements within the shot.”



Modelmaker Kento Gebo wires miniature fluorescent lights for the translight surface of a Gotham City sign, one of many incorporated into the miniature environment.



Giant statues carved out of foam were among the surreal elements embellishing the urban landscape of the miniature Gotham set. A sculpting team headed by Yarek Alfer created most of the massive figures.

In the nocturnal bank heist sequence, Two-Face blows a hole in the side of Gotham Bank while a street celebration is going on in the multicultural Pan-Asia district below. He then hoists out a vault using a chain attached to his getaway helicopter. A vigilant *Batman* releases the vault, causing it to swing back into the bank through the blasted wall. Unfortunately, *the Dark Knight* is left hanging from the end of the severed chain as a gleeful Two-Face orders his pilot to fly through the skyscraper canyons at full speed. During the precarious passage, *Batman* is nearly snagged on the horns and wings of a gigantic devil statue, smashes through a billboard, and ends on a collision course with the Lady Gotham statue gracing Gotham harbor.

The sequence begins with the most elaborate location work in the film, a nighttime enactment of a Pan-Asia celebration created on busy Figueroa Street in Los Angeles. The six-lane thoroughfare was closed to two lanes and dressed with twenty-five-foot-tall storefronts positioned across from an actual bank building. On an adjacent empty lot, the production built eighty feet of skeletal girders to represent a building under construction. Matte paintings by Illusion Arts helped conjure up some of the magic of Pan-Asia Town and extend the location set with surrounding buildings. “The idea was that the Pan-Asia storefronts were built into these super-structures in the manner of the *Blade Runner* buildings,” said Illusion Arts co-founder Syd Dutton. “We scanned in the live-action footage, and Mike Wassel added a digital painting in Photoshop of buildings behind the storefronts along this gigantic corridor. Barbara Ling loved the look of gigantic buildings connected by layers of elevated roads. We had gags throughout, with Fumi Mashimo animating the neon for a foreground Chinese dragon sign that Mike painted, as well as dragging digital lights across the bridges to represent street traffic.”

The ensuing helicopter flight through Gotham recalled the Boss Film Studios shot in *Batman Returns* in which Catwoman dangles from the end of a flying Penguin umbrella. *The Boss* shot was created with an optical move on a bluescreen stunt-woman composited into a multiplane matte painting and miniature Gotham environment. In *Batman Forever*, the technological options were such that a synthetic character would take the risks of a flight deep into the canyons of a miniature city. “Originally we thought of doing the helicopter sequence with a CGI city,” explained visual effects production supervisor Jo Ann Knox, “but once we saw how labor intensive and time consuming that would be, it seemed more beneficial to do it with miniatures.”

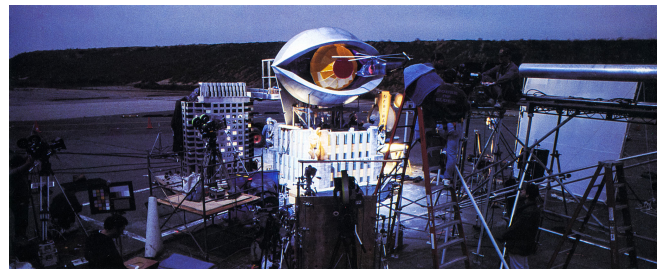
The opening of the scene – which incorporated live-action elements of an abducted bank guard, as well as *Batman* freeing the vault from Two-Face’s helicopter – required special smoke treatment of the background miniature environment to match the atmospheric effects Joel Schumacher had used throughout main-unit photography. To that end, Andrew Adamson devised a multiplane image processing effect that was utilized in the twenty-seven shots that start the sequence. “Joel shot a lot of smoke throughout the live-action,” Adamson noted, “and when you have lights in a smoky environment, it creates the look of saturated wafts of colored smoke – which was a particular challenge for miniatures since you can’t smoke up bluescreen, and motion control isn’t real time. So we ended up shooting different smoke elements on stage and tracking the smoke to match camera motions and angles. Then – mostly at CIS – we would take our backgrounds and digitally extract the window highlights, blooming them through soft-edged mattes of the smoke elements, then put a smoke layer over that and another smoke layer for the foreground. It made the windows look as if they were diffusing through the smoke. We had at least five to six layers in that sequence.”

One of the key elements in the scene was the helicopter model built by John Merritt and Bill Shourt of Private Gardens. To facilitate filming, Durst and his crew mounted the eighth-scale model on its side, attached to a motion control rig capable of all axes of movement. Using a process developed at Apogee, special colored phosphorescent paints were applied to the model – blue for the propeller and bright red for the fuselage – to better isolate the elements during the digital compositing stage. “The helicopter was so black and shiny that whether we filmed with a blue- or greenscreen behind it, the color would reflect on the model and we wouldn’t be able to matte it,” Durst explained. “But with this phosphor process, we could create a matte without any spill problems. Because the paint is a self-illuminating phosphor shot against black, the helicopter, in essence, is its own bluescreen – separating itself so you can pull mattes off the red or blue. Also, because we were not limited by having to have a screen behind the model, we could perform more elaborate camera moves.”

Pacific Data Images motion-tracked to the chopper both a synthetic chain and a computer generated Batman figure. A digital model, together with motion data collected from shots of a performer swinging from a rope, was inputted into the company’s proprietary system which allowed for manipulation and refinement of the database. The motion capture served as a rough guideline, with most of the articulation on the character provided by the digital animators.

Lighting was key to matching the computer generated figure to bluescreen shots of Batman dangling from the chain. “My goal was to integrate Batman into the scene and to make the integration work with adjacent shots,” explained PDI lighting supervisor Jean Cunningham. “We positioned lights in our CG world in the manner of a DP setting up lights on stage. We controlled the quality and color of the lights and of the surface attributes of the CG Batman to make it look like a real guy in a suit. The helicopter sequence was difficult because Batman is small in frame and the environment is huge. He had to be visible, but not unrealistically bright. We had the CG Batman pass through colored lights as he swung through Gotham.”

The monumental statuary of the city also figured into the superhero’s wild ride. “One of our sculpted figures is a giant devil statue whose form suggested itself for a shot in the helicopter sequence where Batman is almost snagged on its horns and wings,” James Hegedus remarked. “The shot was a real



Having foiled a bank heist staged by Two-Face primarily to entrap him, Batman finds himself clinging perilously to a chain attached to a careening helicopter. As darkness approaches, effects crew members prepare for a night shot in which the helicopter – a model tail-mounted on a rod extending from a linear track – smashes through an eye-shaped billboard.



challenge for miniatures. When you see a sculpture on the side of a building that's two or three times bigger than the Statue of Liberty, that's not a scale you're used to, so you can have trouble believing it. Even though we had planned out the sequence with digital animatics, with miniatures there was always going to be tweaking and rearranging. Almost daily we were recomposing shots."

The post-production flight of the figure, tempered glass on the billboard, helicopter with digital-assisted motion control, and motion blur. PDI also incorporated digital neon into the sign and added a computer generated Batman dangling from the chopper and motion-tracked to the shot.

The illusion of the helicopter flying through a billboard was accomplished with pyro charges rigged to blow up a miniature sign just seconds before a rod pushed the aircraft through. "We shot the pyro work at 120 to 200 frames per second," Durst explained. "Then PDI did some motion blur on the rotors so they would appear to be traveling at high speed." The billboard – a colorful eye-shaped sign for Ocu-Wash eye wash – was constructed by Mike Joyce's crew out of eighth-inch tempered glass. The billboard was comprised of thirty-five pieces which, when fastened atop one of the Hudsucker models, rose to a height of seventeen feet. "We made a linear track and positioned the eighth-scale helicopter on a rod with a tail mount and a bungee cord to push it through," Joyce explained. "There were trips on the track that set off the pyro as the helicopter moved down it." To footage of the chopper crashing through the sign, PDI added their computer generated chain and hanging Batman. They also incorporated digital neon into the sign and added fire and smoke to obscure the visible two-inch rod mount that pushed the model through.

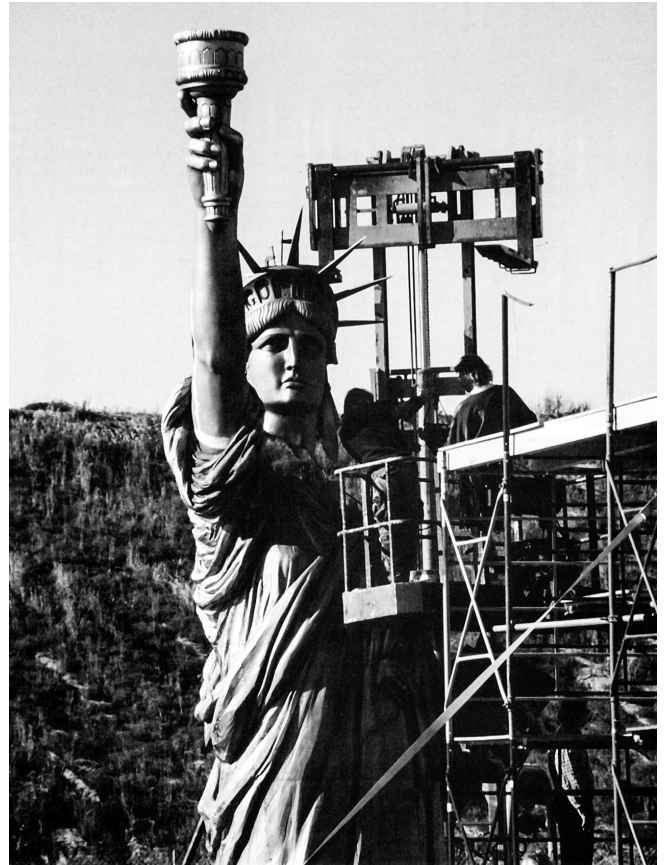
For the climax of the sequence, *Batman* manages to pull himself into the helicopter, only to have Two-face lock the controls and parachute to safety as the aircraft heads toward the harbor on a collision course with Lady Gotham. The action would cut between miniature motion control and live-action special effects work. "At Warner Brothers," Hegedus explained, "the production had a full-scale helicopter stationary on a gimbal with a Lady Gotham model pushed on speed rails toward it. Then we would go to our miniature helicopter being pushed into the statue until it makes contact and blows up. Working drawings for Lady Gotham, based on designs Barbara had created in the art department, were delivered to Mike Joyce who built it in the same scale as the helicopter."

For the impact shot, Joyce discovered that the original Lady Gotham model was not quite big enough, so he engaged Yarik Alfer to sculpt another head that was twenty-five percent larger. From that sculpture, three fiberglass pyro heads were constructed, with a breakaway section in the left cheek where the rotors were to hit. As with the billboard effect, the helicopter was pushed in on a two-inch rod mount, the blades spinning at a thousand revolutions per minute. Unexpectedly, the impact of the blades cutting into the fiberglass head caused the statue to buckle and warp, betraying the illusion. A digital fix was assigned to PDI. "We had to stabilize the image by digitally extracting the shakes," noted facility effects supervisor Richard Chuang. "Where the blade cut into the statue's eye, we replaced the shaking area with a clean plate of the stable head, then re-composited the debris and fire of impact."

The aerial bank heist is followed by another fly-through over Gotham and into Wayne Enterprises. Whereas Gotham in the first sequence was achieved through a combination of models, matte paintings, full-scale set pieces and location sites, this fly-through was achieved using a digital cityscape. "The only way we could do the fly-through approach to the Wayne Enterprises headquarters was CG," Schumacher explained. "The shot was supposed to look like a helicopter

shot, but since it would have been too dangerous to do practically, we had to create this entire landscape.”

The aerial journey would cover an estimated half mile of airspace, passing over a chasm of Gotham skyscrapers, wiping behind a building, opening onto a panorama with dozens of skyscrapers lit by the setting sun, flying over Gotham River and toward Wayne Enterprises, with the corporate headquarters rising like an art deco jewel complete with monolithic statues and cascading waterfalls from a gigantic power plant built into the structure.



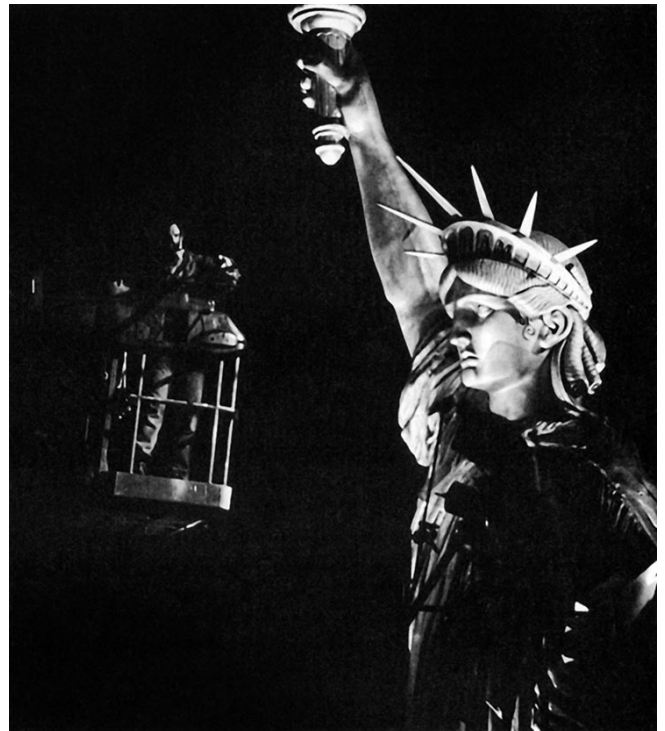
Two-Face sets the helicopter, with Batman aboard, on a collision course with Lady Gotham. A large-scale model of the statue is readied for a shot of the fiery crash.

The task of producing the computer generated city shots – which included not only the fly-through but backgrounds for a falling digital *Dark Knight* – went to Warner Brothers Imaging Technology, a new division for the studio that started up in 1994. With John Scheele as senior visual effects supervisor, the company began work on the digital Gotham fly-through. The assignment made sense in a strategic context, since Warner Brothers is part of the massive Time Warner media conglomerate that also encompasses DC Comics and its whole pantheon of superheroes, including *Batman*, *Superman* and *Wonder Woman*. Creation of a computer generated city for *Batman Forever* would therefore represent the beginnings of a digital backlot that could be applied to the differing needs of any future comic book movie. “Part of the reason we went after the city work on this film,” noted WBIT visual effects production manager Amy Harrington, “is that one of our goals is to be an asset base for Warner Brothers. In building the city, we have assembled a huge library of high-rez buildings, textures and architectural details that can be part of Gotham or Metropolis – or even be made to look like Cleveland.”

A green light was given to do the scene digitally after initial tests showed that WBIT’s virtual cameras could get very close to sunlit building surfaces and still retain credible quality. Testing at the company’s Sherman Oaks facility also included a previsualization phase during which John Dykstra roughed out a computer graphics layout as well as the basic flight path for both the CG fly-through and the Two-Face heist sequence. “We used to plan out camera moves with miniatures and a video camera,” Dykstra noted. “Now computers animatics can bring storyboard drawings into 3-D form. Our animatics became the template we used to photograph the miniatures and, in some cases, generate the CGI buildings. Because real-time reproduction is not a computer forte, there are a limited number of details you can put into any given scene; but once you’ve got a mathematical model of a building, you can use



Effects crew members add last-minute detailing to one of several fiberglass heads built to accommodate multiple takes. Breakaway sections in the cheek were rigged to shatter when struck by the helicopter’s spinning rotors. Upon filming, however, the crew discovered that the blades’ cutting into the head caused the statue to buckle and warp, requiring a digital fix by PDI.



it as a CG building, encode it into an animatic, or use it as a previsualization tool for figuring out camera angles.”

As with the billboard effect, the miniature helicopter is tail-mounted on a rod prior to being pushed into the statue to simulate the collision.

To construct virtual Gotham, WBIT brought on a team of architects, with the two principals, Lance Hammer and Curtis Auspurger, experienced not only in urban design but in using Alias and other modeling and rendering systems. “In building our Gotham City,” Hammer said, “there was the question of how to create all the geometry and render all the buildings with the available tools. Because of all the pieces of geometry and the texture maps, the rendering time was just phenomenal. It really pushed the limits.” Dealing with the massive amount of data as a single file was impossible, so the sequence was divided into twenty files that would be composited and rendered at the end. “Wherever possible, we rendered groups of buildings relative to their distance from camera,” explained John Scheele, “with the levels closest to camera rendered with full 3-D smoke and diffusion and distant buildings rendered with flatter, more gradated veils of smoke elements added separately. We felt it was necessary to render foreground buildings with 3-D atmosphere to reveal realistic depth. It was a shortcut to render the flat smoke separately as opposed to rendering it as 3-D into the scene, but our tests showed it would have the correct look and perspective.”

Four solid months were devoted to actual construction and rendering of the virtual city, during which time photographic texture maps were laid over the geometric shapes of the digital Gotham. “Using sophisticated texture maps with simple polygons was a work-around that solved a lot of problems for us,” stated Hammer. “All of the texture maps were extremely high-resolution and based on real photography applied as a kind of sophisticated decal. With Photoshop, we would then add the bump maps and staining details. The texture maps, which had the color properties of real metal, had to look real because we got to within inches of them.”

To capture building details for the texture maps, members of the WBIT crew scoured the streets of Los Angeles with still cameras. John Scheele, Amy Harrington and Stephen Brand also photographed New York cityscapes, including the actual buildings and street sets lit by main-unit director of photography Stephen Goldblatt. “We waited until the lighting was all set on the location,” recalled Brand. “Then we would step in between takes and shoot the building surfaces. We also shot the same details later under full flat lighting to be used more generically.” Such images would prove extremely valuable in detailing the computer generated cityscape. “Computer images tend to be clear,” Harrington noted, “but real buildings have years of accumulated stain and dirt and gritty textures. So, when John Scheele and I were on location, we photographed these beautiful stains and mapped them onto other textures to put onto our digital buildings.”

To capture the precise look of the giant statuary that distinguishes Gotham, prototype sculptures were sent out to Viewpoint DataLabs for careful digitizing. “We made an effort to use other scanning techniques,” stated Scheele, “but Viewpoint really has this method down. The two giant Indians guarding the spillway near Wayne Enterprises were encoded in that manner, as was the huge statue of Atlas holding up an astrolabe. There were also many statues that were treated by our artists directly in Alias, and several done by using the raised relief techniques available in the Macs.”

After an introductory scene inside Wayne Enterprises, the bat signal alerts the Caped Crusader that his services are needed. Inside his posh office, Bruce Wayne makes a quick exit through a trapdoor in the floor which deposits him into a luge tunnel where he is propelled – at hundreds of miles an hour – towards his subterranean batcave. The luge and tunnel were all-digital effects produced by Pacific Data Images. “Doing the luge sequence in CG gave us the flexibility to put the camera anywhere and do camera moves that would have been physically impossible,” Adamson asserted. “In CG, you can move faster through an environment because you can keep extending your set – something you can’t do with miniatures.”

With their digital luge rocketing through miles of virtual tunnel, PDI discovered that established rendering procedures did not apply. “In normal rendering, you describe geometry, objects, motion, surface textures, lights and so forth,” said company technical director Wendy Rogers, “but the luge was moving so quickly, and covering so much ground, that there was too much data. For the luge to travel at such a high speed, we had to render everything – luge, different sections of tunnel, lights – as separate passes. We applied surface textures, scanning in different metallic looks and lighting schemes in the various tunnel sections. The luge also had its own light source, an ethereal blue glow underneath the vehicle.”

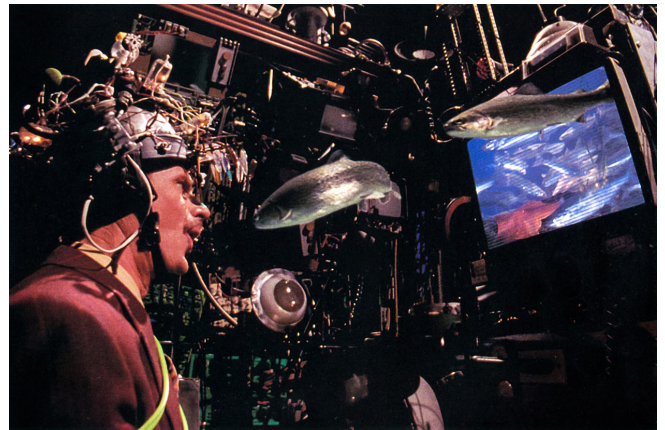
Because of the high speeds that were specified, it was also necessary to devise a new technique for creating motion blur. “In normal CG motion blurring, the moving object is tracked frame by frame,” Richard Chuang explained, “but our luge was moving so fast that it was never in the same place in frame; so it was difficult for the computer to read it. In real life, you could photograph a moving object and you would have motion blur; but in CG, you have to go extra steps to approximate a real camera. We had to track the luge each 1/48th of a second that the virtual camera shutter was open per frame. That way we could get all the subtle motion blur, as well as add shake to the moving virtual camera.”

Once the luge has safely deposited Bruce Wayne into the batcave, the millionaire businessman assumes his *Batman* persona. The batcave had always been a key physical and psychological environment in the comics, but the first two movies had utilized only minimal batcave sets extended with matte paintings. In Schumacher’s film, *Batman*’s cavernous lair would be realized as a sprawling tri-level set – big enough to accommodate the batmobile’s departures and arrivals – that also incorporated a lower lagoon housing a full-scale batboat.

Like many of the film’s major sets, the batcave was erected at the former Spruce Goose hangar in Long Beach. One hundred ninety feet from floor to ceiling and some four hundred feet in diameter, the famed dome hangar allowed the batcave set to rise eighty feet high, with lighting grids in the darkened structure creating the illusion of its rising hundreds more feet in the air. The three levels,



For an establishing fly-through over Gotham and into the headquarters of Wayne Enterprises, Warner Brothers Imaging Technology produced a wholly computer generated three-dimensional cityscape, complete with detailed skyscrapers and statuary.



Wayne Enterprises plant manager Fred Stickley (Ed Begley, Jr.) becomes an unwilling test subject for the Riddler’s prototype invention – a television adapter that transforms video images into 3-D holograms while surreptitiously sapping brain waves. For a shot of three-dimensional fish emerging from a television screen, Composite Image Systems digitally extracted the fish from bluescreen tank photography and matted them into space. Color shifts and other surface treatments were added to link the fish with the video environment and simulate the signal beam breaking up.

each connected with steps, included such upper-cave features as Alfred the Butler's crime lab, an armored vault, a weapons display, a wall of monitors electronically connecting *Batman* to the outside world, and, for the batmobile, a central, hydraulically-powered steel turntable, thirty feet in diameter, that could not only rotate but also raise and lower twenty-four feet. The middle section was a rugged cave, unadorned by the technological trappings of *Batman*'s crimefighting operation, while the lower level was taken up with the lagoon in which the batboat is moored.

The practical batcave set was expanded with models to fulfill specific aesthetic and plot requirements. For a scene of the batwing hanging, batlike, from a cave wall, Grant McCune Design built a twelfth-scale fiberglass batwing model – about two feet wide and three feet long – and an accompanying cave miniature twenty-five feet tall and twelve feet wide. Footage of the batwing hanging from the miniature cave wall was composited into a live-action wide shot panning up from the batboat past *Batman* and Alfred. A traditional Illusion Arts matte painting both extended the batcave environment and blended the two plates. “We try to integrate traditional matte painting and digital technologies,” observed Syd Dutton. “For the shot in the lower batcave, it just seemed that all the elements would blend more easily with a traditional approach. Rob Stromberg and I created a three-by-five-foot glass painting with the live-action rear-projected in the lower left section and the model photography rear-projected in the upper right.”

The inner batcave would also provide an atmospheric setting for a flashback – inspired by Frank Miller's graphic novel *The Dark Knight Returns* – in which a six-year-old Bruce Wayne, recently orphaned, discovers the vast cave beneath his family estate and is transfixed by the screeching bats which inhabit its darkness, planting the emotional seeds of his future alter ego. For the film reenactment, two animatronic bats – in differing scales – would be created by Rick Baker and his Cinovation Studio. A cable-operated version with a five-foot wingspan was built for distant shots of the bat, while another, much larger, radio-controlled version with an eighteen-foot wingspan was built to confront Val Kilmer in closeup.

The Cinovation bat team included Mike Elizalde, Eddie Yang, Matt Rose, Claire Manion and Jurgen Heimann, with mechanical design provided by Mark Setrakian. Mechanisms for the smaller bat were operated by a puppeteer working a joystick with two cables connected to a junction box from which tubes extended to support the puppet's weight and transfer both a torsional movement to flap the wings and a concurrent push-pull movement to extend the wings. “The junction box changed what was basically a pulley action into a linear motion,” explained Setrakian. “I had to distill down the motion of the bat wing to two axes per wing, with two cables to extend and retract and two cables to flap forward and backward. The pivot points for the flapping were deep inside the body, so the entire body moved. There were silicon pectoral muscles, with mechanism support plates that got squeezed, and push rods inside the tubes that controlled the rod linkage of the wings. Once the design for the wings on the small bat was worked out, it was a simple matter to scale it up for the big bat, with motors and a linear actuator to extend and flap the wings.”

Initially, Baker harbored concerns that the large bat's size would make it difficult to animate the wings. “I was afraid we wouldn't get realistic motion on the big one,” Baker admitted, “because bats are not that big and they flap their wings really fast, with their elbows going in and out in one motion. But the big bat, in many ways, worked better than the little one. We mounted it on a counterweighted parallelogram dolly that could pivot and tip the body as if it were flying. The rig

was pushed manually on a motion control dolly track, which made for a smooth ride.” Although both bats were filmed, only the smaller one made the final cut.

Also excised from the film was a flock of some three hundred computer generated bats created by MetroLight Studios. Technical director Jim Berney had written special software that allowed fellow tech director Rosa Farre to create a flight of bats that swirled past Bruce Wayne and Alfred during a trip to the batcave’s lower levels. The company was also in charge of creating the iconic bat signal which, with some eight shots, would have more prominence than in the previous films. “At MetroLight, we have mastered the more difficult, physical-based effects such as water, smoke, fog and hair,” observed supervising producer John Follmer, “which is why we were well suited to do the bat signal. John Dykstra wanted us to take the signal into more of a 3-D realm. We created and comped a beam, the signal itself, and the clouds upon which the signal is projected using our proprietary and commercial software.”

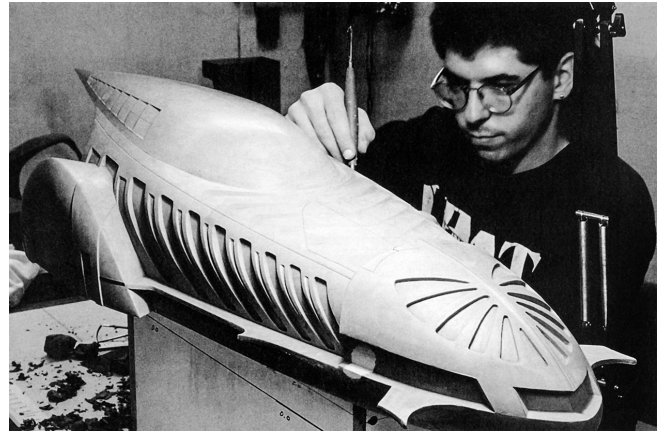
In *Batman Returns*, the bat signal had been accomplished in-camera using artwork projected onto fiberfill clouds. With the new generation of digital tools, however, MetroLight would be able to produce an even more dimensional look. The company began with a cloudy daytime sky plate that was digitally processed and combined with computer generated clouds to suggest a night sky scene. With a little digital sleight of hand, lead technical director Tomás Rosenfeldt distorted the cloud picture to provide a rippling effect when emblazoned with the computer generated signal. “We ran a random distorting function throughout the cloud still image to make it seem as if it was rippling, even though it was not moving,” Rosenfeldt said. “It was basically a procedural texture-mapping effect to make the beam appear as if it were going through cloud mass. And since one cloud layer looked too flat, we created ten layers to give the impression of depth, then projected the signal onto those layers.”

Later in the film, the Riddler would mock the bat signal by projecting his own signature question mark onto the Gotham skies. The question mark signal and subsequent zoom-back revealing all of Gotham beneath it would prove to be one of Illusion Arts’ most challenging digital shots. Digital supervisor Richard Patterson and matte artist Fumi Mashimo studied the dispersion of a laser beam in milky water as a guide to simulating the scattering of the Riddler’s green laser in the clouds. Mashimo then used Form Z and Electric Image software to create an invisible 3-D conical projection of the question mark. Where the projection intersected the moving cloud geometry, it formed the outline. Diffused and hard outlines were wiped on with animation, following the edges of the cone. The ‘scatter’ element within the clouds wiped on with separate layers of soft-edged animation, and a scanning effect wrapped progressively around the cone as the question mark grew. Serving as the ‘period’ to the question mark was the bat signal. “Working from MetroLight’s established look and image data saved us a great deal of time,” explained Illusion Arts co-supervisor Bill Taylor. “It left us freer to develop the pull-back and laser animation.” Patterson, Mashimo and composite technician David Williams combined dozens of 3-D and 2-D elements with the master Gotham matte painting to create the final zoom.

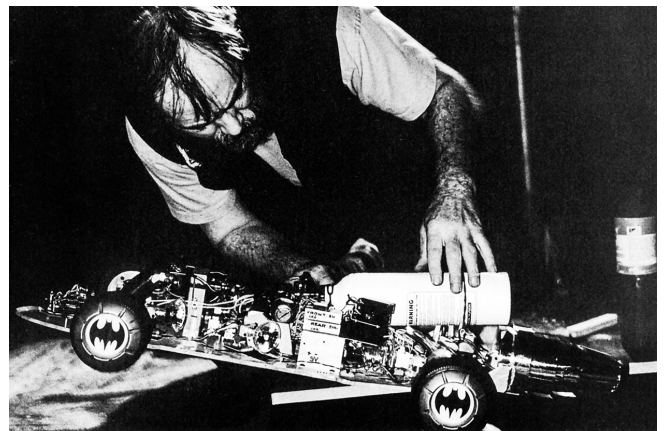
Once alerted to the distress signal, the *Caped Crusader* had his choice of land, sea or air conveyance to transport him from the batcave to the city. The famed batmobile was dramatically redesigned for the third film, with the streamlined body combining a ribbed look emulating both art deco lines and an H.R. Giger-style bone structure, set off with sleek wings down the canopy and on each rear fender. The job of building the twenty-eight-foot supercar went to TFX, a new company specializing in motion picture vehicle design and construction. The firm had won the assignment with a sixth-scale display model that was ultimately digitized and transformed into a three-dimensional blueprint used in fabricating the fiberglass body. Scaling down the same data, TFX also constructed a miniature batmobile that was used for several key scenes – most notably one in which *Batman* drives the vehicle up the side of a building to escape Two-Face and his gang.

In addition to the new design, the production wanted the batmobile to have more engine firepower than its previous incarnations. “We had a solid aluminum burner in the model car,” said Charley Zurian, a partner in the company with previous experience designing and building GM automobiles, “and by remote control we could open the valves and fire it up. The big car also had a burner powered by two twenty-five-gallon propane tanks. At maximum power it could shoot out a flame twenty-five feet and produce searing heat up to a hundred feet away. The flame was so hot that when we were testing it in our shop – which is twenty-five thousand square feet and twenty-five feet from floor to ceiling – it set off the sprinkler system.” To impart a more dramatic look, an internal mechanism manually controlled by the driver sprayed red ‘fog juice’ into the spewing flame. “The miniature used propane shot with strontium nitrate for a much brighter flame.”

The batwing, featured in the film’s climax, was one of the key pieces of miniature photography overseen by Boyd Shermis who – like Eric Durst and his crew – spent months working out of the old Hughes Aircraft hangar. For the batwing shots, Grant McCune Design produced a twelfth-scale model which was attached to a motion control mount. Twenty-fourth-scale tunnel miniatures, also built by the McCune team, were used for background plates into which the craft would be



The batmobile – altered from previous incarnations to include a more streamlined body, with sleek wings running down the canopy and rear fenders – was built full-scale and as a miniature by TFX. To promote the illusion of intense engine firepower, both miniature and life-size versions of the car were equipped with propane burners for spewing flame as the batmobile fires up to maximum power. Modelmaker Paul Ozzimo sculpts the body of a sixth-scale miniature used in several key scenes.



Crew member David Beasley adds fuel to the model flame-car in preparation for a shot of the vehicle doing a wheelie down an alleyway.

composited for its flight from the batcave to the surface world. “The original bid called for a tunnel carved out of rock,” McCune recalled, “but Barbara Ling and James Hegedus later changed it to be more like Carlsbad Caverns. We made sixty feet of tunnel out of the usual chicken wire, wood, tin foil and shot foam. We built about five different sections so they could be rearranged, with the longest section about twenty feet long and the shortest about twelve. The sections averaged two to six feet in diameter, since the bat tunnel was supposed to go from large to small, making for a very scary ride.”

The horizontal bat tunnel sections were designed with openings to facilitate filming by a motion control camera moving on a parallel track. The geological aspect of the tunnel would figure in Shermis’ flight choreography. “John Dykstra wanted to do something sleeker than the traditional gliding moves you make when you’re out in space,” Shermis explained, “with the batwing maneuvering like an F-16 fighter. John gave me the basic direction, but left it wide open to my interpretation. We shot all the tunnels first and then had to put the batwing into that environment. We had shot video of the tunnel camera moves, which we used as a background to line up the flight path for the foreground batwing element, plotting and mapping out the flight on the fly. Although the programs were generally light-years apart, there were some shots in which we could use the same motion control data, particularly if there was a banking move in which the batwing had to do a counter-roll during its flight through the tunnel.” Rather than using bluescreen or greenscreen for the model photography, Shermis opted for orange phosphor screens which he determined would allow for better matte extraction in the digital environment.

Compositing the batwing and tunnel elements fell to Composite Image Systems. The company, which had a longstanding professional relationship with Dykstra from the Apogee era, had a core team of fifteen digital artists concentrating on nine sequences and ninety-nine shots for the movie. The four-cut batwing launch sequence alone required CIS digital compositing supervisor Don Lee to combine twenty-seven passes ranging from batcave and batwing beauty passes to lighting, smoke and engine glow passes. “We’ve created our own software and hardware system that allows anyone to interact and quickly evolve an image in low-resolution that we can then replicate in high-resolution,” explained executive producer Joe Matza, a company co-owner with Rob King. “We also use Flame or other systems where appropriate. In the case of the launch, Boyd took the high-rez footage, got on the Flame with our Joni Jacobson and, with the light pass edges from the 2K image, painted it on the batwing to add a subtle contact light. Many of our shots involved such detailing.”

The *Caped Crusader*’s entire arsenal of vehicles, tools and weapons would be employed as he battled both the Riddler and Two-Face. Fans who had never cracked a Batman comic book were already likely familiar with the Riddler from actor Frank Gorshin’s turn in the old TV series. Two-Face, however, had failed to grace the show during the three seasons it was on the air. But for fans of the comics, Two-Face not only belonged on the ‘A’ list of bat-foes, he literally embodied the dualistic tone of the *Dark Knight*’s world. Two-Face had been designed by *Batman* creator Bob Kane as a conceptual variation on Dr. Jekyll and Mr. Hyde. A tragic figure, he had once been the handsome Harvey Kent, a crusading Gotham district attorney, until acid thrown at him by a gangster disfigured half his face and unhinged his mind. (The character’s name inexplicably changed to Dent later in the series, possibly the result of a typographical error.) Two-Face’s modus operandi entailed crimes revolving around the numeral two, with a caper initiated by the flip of a silver dollar. If the scarred

side of the coin came up, law-breaking anarchy would be in store; but if the clean side surfaced, Dent's law-abiding instincts would prevail.

For his role as Two-Face, actor Tommy Lee Jones would have his features bisected by makeup – the right side of his face left intact and the left side rendered a monstrous mass of ruined tissue. The job was a natural for Rick Baker, whose career had been inspired by the classic Universal horror makeups of Jack Pierce. Using the computer as a design tool, Baker began the creative process by scanning in photos of Jones and working out a range of Two-Face visages. “If it weren't for Photoshop, I probably wouldn't have designed the particular makeup I did for Tommy Lee,” Baker observed. “You can do things with a computer you just can't do with rubber. On a computer you can do a painting various ways, change things and save it. It frees you up to be a lot bolder in the design phase.”

As with all effects work based on two-dimensional drawings, the challenge was to create a makeup that was true to its comic book origins but could still work in three dimensions with a real actor. “The Two-Face stuff in the comic books had this big eye and a whole bunch of teeth exposed,” Baker recalled, “and to create that would have required an external prosthetic on the face and rubber teeth, which can really limit the acting. I had wanted to use a contact lens and pull down the skin under his eye, but Tommy Lee wouldn't go for it – the actor has a lot to do with how the makeup evolves. I did the first makeup tests in bizarre colors such as hot pinks and a lot of iridescent powders – something like twenty different colors. Since it was based on a comic book, I didn't want to make it look too real. It was intentionally glossy and atomic-looking – a really insane look.”

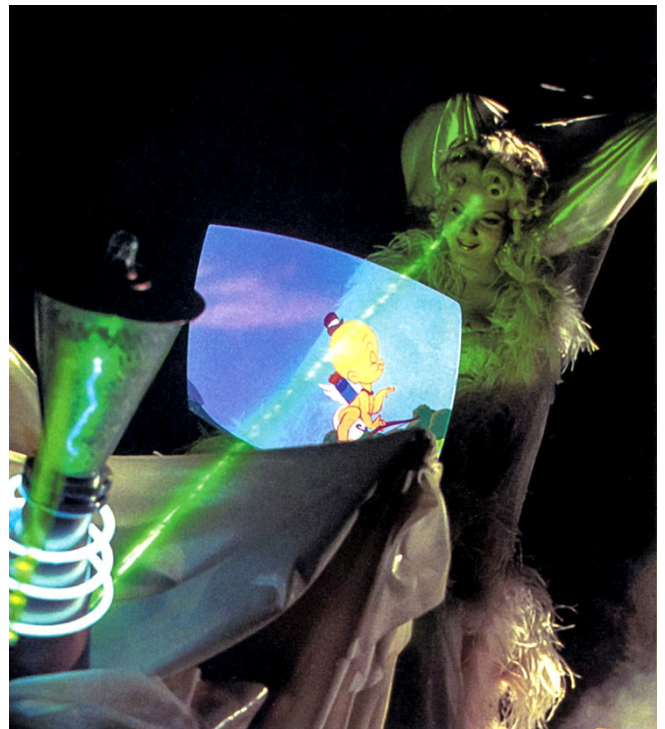
The division between Two-Face's normal and scarred sides, which Baker had originally conceived as a gradual blend, was also revised to reflect the director's idea of a straight-line split. “I originally had it shaded like a step in the skin, with the burned side raised,” Baker explained, “but I eventually eliminated that. The skin was split down the middle with magenta on the scarred side and normal corrective makeup on the other side. And since Tommy Lee would be playing Two-Face for at least fifty days of filming, we eliminated a lot of steps that would have added to the application time without making much of a difference in the final look.”



Pursued by Two-Face and his cohorts, Batman escapes by deploying a grappling hook and cable and driving his batmobile straight up the side of a building. The shot was accomplished in miniature using the TFX sixth-scale vehicle on a like-scaled alleyway set built by Grant McCune Design.



A rooftop POV of the Dark Knight leaping to a bridge far below featured a digital matte painting rendered in exaggerated perspective by Bob Scifo of WBIT. A digital Batman and cape, along with fog and smoke effects, were then composited into the background plate by PDI.



At Two-Face's hideaway, girlfriend Sugar (Drew Barrymore) experiences the Riddler's latest device for stealing cerebral energy. Computer generated beams, consisting of a core of animated particles, were created by CIS and tracked into the live-action shot, along with a floating TV screen which was color-balanced digitally.

Working with Baker was Ve Neill, who would apply the foam latex makeup during production, and Yolanda Toussieng, who handled the two-toned wigs. “The scarred-side appliance was five to six pieces,” Baker said. “During the test, we applied the initial piece that covered Tommy Lee’s head and part of his forehead and his ear, which I stuck flat. The problem was that if anything was off-kilter, the other pieces would not line up correctly; so I made vacuform stencils to glue on Tommy Lee to mark the exact placement of the pieces. The first major piece would go on, followed by a brow piece, then a little piece under the eye, a major cheek piece and a piece for the upper and lower lip. It was like putting together a jigsaw puzzle.”



The Riddler treats Two-Face to a jolt of stolen brain energy.

It would be a Two-Face crime that would finally usher Robin into the *Batman* movie saga. Robin, the *Boy Wonder*, became part of the comic book series in 1940, after a year of solo crime fighting on the part of the *Dark Knight*. In the comics origin, Dick Grayson, who with his parents formed a high-flying circus trapeze act, had been orphaned when his parents fell to their deaths during a performance. When it was revealed that gangsters had treated the ropes with acid as part of a terrorist shakedown of the big-top operation, sympathetic *Batman* took the youth under his wing as a crimefighting sidekick – and the Dynamic Duo soon brought the criminals to justice.

Since the first Tim Burton film, scriptwriters had attempted to write Robin into the big-screen proceedings. For *Batman*, screenwriter Sam Hamm had recounted Robin’s origin with a wild, third-act scene of *Batman*, on horseback, pursuing the *Joker* through Gotham Park even as the criminal’s van crashes into an outdoor circus, bringing down the high-wire platform and killing Dick Grayson’s aerialist parents. The scene was discarded, along with the *Boy Wonder*, early in the production. Subsequent Robin rumors had suggested that the famed character would be introduced in *Batman Returns* as either a black youth or a young girl. Neither proved true.

With twenty-five-year-old Chris O’Donnell cast in the role in *Batman Forever*, it was clear the production was going for a Robin with attitude – more a younger partner than the boyish sidekick of the comics and TV show. The circus milieu of the character’s comics origins would be approximated, however, with a sequence at the Gotham Hippodrome. The grand set was erected on a Warner Brothers soundstage with six thirty-foot statues supporting a black-and-white silk tent, sixty feet tall and eighty feet in diameter, covering five hundred seats and a full trapeze rig. An ultra-wide 5mm lens developed by Panavision was employed to shoot the Hippodrome set – as well as a climactic scene at the Riddler’s hideout – taking in the whole environment in one shot without any fish-eye effect.

As Two-Face invades the circus, with Dick Grayson scrambling to the Hippodrome roof to dispose of a massive bomb, the production shifted from the soundstage set to a combination of bluescreen elements and Illusion Arts matte paintings. “The production wanted a magical look for the Hippodrome, which we felt we could better create with oils than the more hard-edged look you get

with a computer,” said Syd Dutton. “Although we did a traditional matte painting for the master shot, we still took a photograph of it, digitized it, and had Mike Wassel digitally enhance it and add some layers of smoke elements that John Dykstra had sent us.”

On the master shot of the Hippodrome, a camera push-in was accomplished with some traditional, low-tech matte painting tricks. The illusion of a perspective shift was achieved with foreground elements of two-foot male figure sculptures on movers and a latent image effect on a single painting of the Hippodrome and the river and city beyond. “We divided the painting plane into two separate elements with an in-camera split-screen,” Bill Taylor explained, “so the camera move on the Hippodrome foreground would move at a faster rate in relation to the background view.”

“Another simple, but effective, painting had a bluescreen element of the Hippodrome rooftop with Two-Face’s bomb rolling down the roof to an extreme down-shot of the harbor and water,” Dutton added. “We had a water plate, but we didn’t think it worked very well; so we came up with the idea of doing part of the roof, the dock, and the water all as a matte painting, with the bomb element optically composited. To create reflections on the painted water, Lynn Ledgerwood used two sheets of glass, with a resin rippling through the surface, that Mark Sawicki shot separately on a fixed matte camera. That photography was then combined with the water in-camera as another split-screen matte.”

Like Two-Face, the Riddler would prove to be both diabolic and criminally unhinged. In the film, the character – played by Jim Carrey – is first introduced as Wayne Enterprises employee Edward Nygma, a brilliant techno-nerd who worships Bruce Wayne from afar. Ignored and rejected, Nygma takes his revenge in the form of a little invention he has cooked up: a TV adapter box that transforms an ordinary televised picture into a 3-D hologram that floats free from the set. Unbeknownst to captivated viewers, the device is actually stealing their cerebral energy and transmitting it to a collector at the Riddler’s hideout on Claw Island, where the villain hooks himself up to the incoming, brain-expanding energy.

Nygma’s initial test victim, a Wayne Enterprises plant manager named Fred Stickley, is subdued and forced to wear a prototype headset. With a television clicked on to a sport fishing show, Stickley



Matte artist Syd Dutton and cameraman Mark Sawicki of Illusion Arts prepare to shoot one of the matte paintings created for the film. The scene – an establishing shot of the Gotham Hippodrome where Batman first encounters Robin performing in a circus act – was enhanced by three-dimensional miniature statuary positioned in the foreground for added depth.



Modelmaker Smokey Stover of Grant McCune Design completes work on a sixth-scale batwing used in a climactic battle scene. Built by Stover and Edward Lawton, the versatile plane was rigged to jettison its wings and convert conveniently into a batsub upon submerging in water.

stares entranced as fish and fisherman seemingly emerge from the set and the brain-sapping begins. “Visually, the TV images have a synthetic quality, with color shifts,” explained Joe Matza, whose Composite Image Systems assembled the thirty-seven cuts in the sequence. “They’re not quite the same resolution as the surrounding scene.” To create Stickley’s fishy vision, CIS was supplied with footage to treat and matte into the blank TV screen on the live-action plate. For the transition of the fish swimming out of the set, a fish-filled water tank was photographed in front of a bluescreen which allowed the effects company to extract the fish and matte them in space. The Flame system was used to create color shifts and other surface treatments on the fish, linking them to the video environment from which they had emerged.

“The fish were always a constant element in the design,” Matza explained, “but the look of the shots went through several iterations. John Dykstra’s original idea was for the fish to have a green, phosphorescent surface glow. Later that was changed to the final look of them shifting color as if the signal beam was breaking up. Another change was the fisherman casting his line, which originally was going to zoom out of the screen. Instead, Andrew Mumford, one of our digital compositing editors, used Flame to take the original photography and create a streak image that was broken up. What made the shots challenging is that we see the television, the beams, and the actors, with Jim Carrey often behind what comes out of the TV. We had to use digital rotoscope techniques for that.”

To meet the Riddler/Two-Face challenge, Val Kilmer’s *Batman* would be a more action-oriented figure than he was in the Burton films. There were, however, several *Dark Knight* action scenes too dangerous for even a seasoned stunt performer to attempt, including a six-hundred-foot fall from the roof of a Gotham hotel and another jump from a rooftop to a bridge. Both a digital super-stuntman and a CG cape would be created for the scenes. “Everything in the picture was done to achieve a particular stylization,” Dykstra commented. “*The Batman* and cape of the comic books and graphic novels have characteristics different from what a real person or a real cape would have; and we wanted to recreate that stylized sense of movement. For the six-hundred-foot fall, our CGI superhero allowed us to give the character the graphic quality of the comics by controlling the cape and its relationship to the character, something you could never do with a real stunt person.”

Batman’s fall from the rooftop of the Ritz Gotham, with the hero deploying his cape like a parachute for a safe landing, would not only feature a digital *Dark Knight*, but another computer generated city environment from WBIT. Dykstra’s design for the fall – a continuous shot with a camera move following the plummeting Crusader, then accelerating past and whipping underneath him – would have been an almost impossible feat for even the most imaginative director of photography. “During the scene,” said Dykstra, “we go with *Batman* as he falls and deploys his cape. The look is like that of a skydiving camera – not something you would want to attempt in a practical sense. But with computers, you now can have an invisible camera that doesn’t need to be attached to anything and that can go anywhere, even through walls.” The breakthrough CG hero utilized motion capture of a performing gymnast recorded by Acclaim Motion Studios. “We set out to do motion capture for our animated figures at a time when motion capture was, at best, a relatively unsophisticated technique. But we had the good fortune to work with people at Acclaim who had developed a prototype system that provided us with the high-resolution data we were able to use as the template for animating our figure.”

Before a vendor was selected to create the CG superhero, a number of effects houses were encouraged to compete for the assignment. Each company was supplied with the motion capture data, a WBIT background city and the same camera moves. Pacific Data Images was finally awarded the job after producing a continuous shot of their computer generated *Batman* landing softly as the cape arrests his fall, then walking away with a roll of the neck and a shrug of the shoulders. The rough test was so effective that it was cut into the theatrical trailer, although the look of the shot would be changed appreciably for the final film. “One of the first digital stuntmen was the lawyer that gets eaten by the T-rex in *Jurassic Park*,” stated Richard Chuang. “This was the next logical level.”

Heading up work on the digital *Dark Knight* was technical supervisor Dick Walsh and animation supervisor Raman Hui. “Creating a character that’s basically a black rubber suit at night was perfect for the current capabilities of digital technology,” Walsh observed. “Dykstra arranged for Viewpoint DataLabs to scan and digitize a sculpture which we then took and modified to work with the Acclaim motion capture data. I was also provided with a low-rez version of WBIT’s in-progress cityscape forms that would go behind our falling character. To me, one of the most amazing aspects of the work was the way our proprietary system could take the motion capture data, our own animation, and use a parallel animation system to blend the two.”

Another CG *Batman* shot – a rooftop POV as Chase Meridian watches the *Dark Knight* leap to a bridge far below – was designed to look exactly like a comics panel, with a shadow of the figure appearing as a graphic bat silhouette image on an adjoining building. The shot, with its exaggerated perspective of the nighttime cityscape, would be accomplished as a WBIT 3-D matte painting.

“Because there was going to be a CGI *Batman*, we figured it would be better to create our element in 3-D,” said WBIT art director Bob Scifo. “It really went beyond the parameters of a painting because it was created from a 3-D model within the computer.” Scifo, who had come out of a traditional matte painting background, utilized StrataSTUDIO Pro on a Macintosh. “Instead of a brush and oils, you draw with a cursor or an icon that looks like a brush. From my matte painting experience, I learned how to give impressions of things, the mood and essence rather than every brick on a wall, which also helps when creating images in the computer. For Chase’s POV, I set up the cameras, then shot 3-D wire-frame with textures applied to the surfaces and reflections. In the street below, I put animated headlights. As a matte painter, you always try to get action and motion into a shot, to create a feeling of space and avoid making it look two-dimensional. On this shot, I was able to touch up the image just as I would with a painting; but then I could add movement to it by burning in a three-dimensional headlight moving across a building.”

Toward the climax of the film, Two-Face and Riddler team up at the Claw Island lair. The concept for the island – created both as a miniature and as a full-size soundstage set – was of an abandoned helium distillery with hundred-foot-tall glass globes, one of which was the throne room where the Riddler received the collected brain energy streaming in from Gotham.

The Claw Island model was ten feet tall, with a welded steel structure representing four columns of the old plant and a motion controlled pyrex glass cone for the brainwave collector. Throughout were some nine hundred tiny tungsten lights and dozens of moving spotlights. The jangling action of the incoming energy captured by the collector was realized as a laser effect. "We came around to the idea of employing lasers for the effect," explained Boyd Shermis, whose team was in charge of the Claw Island shots, "but we modified the technique with a little experimentation. Essentially, we took lasers and bounced them around into a cylinder of crumpled mylar placed on a motion control rotator. By defracting the beam, we got different colors and swirling patterns of laser light bouncing around inside the cylinder. We could then project those patterns onto the surface of the cone collector itself."

For the digital compositing artists at CIS, the establishing shots of Claw Island were a complex combination of miniature island beauty pass, lighting passes, matte pass, CG beams and other elements. "For the sky, we used multiplane techniques, developed by Andrew, which entailed taking some still photographs of clouds, scanning them at very high resolution, and putting some perspective manipulations and camera moves on them," Joe Matza explained. "Then we would take another layer of clouds and move the cloud elements against each other. On top of all that, we laid in electrical discharges and the light and smoke passes."

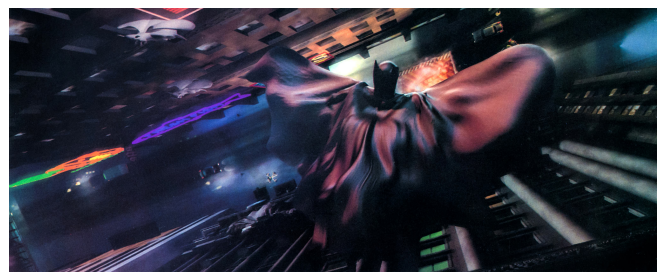
Claw Island was the setting for the end game, with Chase Meridian in the clutches of the villainous pair. To the rescue come the Dynamic Duo, with Batman arriving by batwing and Robin by speeding batboat. The Riddler has prepared for such an eventuality, of course, by stringing underwater mines to take out the batboat, leaving Robin floundering, while a deadly ray severs a wing from Batman's plane, causing the aircraft to hit the water. Ever prepared,



A twelfth-scale batwing hangs on a miniature section of the batcave wall.



For an establishing shot of the Riddler's Claw Island lair, a miniature set was built and filmed motion control. Digital artists at CIS enhanced and composited the multiple passes required for the shot combining elements such as lights, foreground and background smoke, layered laser effects and a synthetic sky.



Batman pulls a lever, ejecting the wing attachments and converting the plane into a submarine.

Both the mine explosions and the batwing crash and sub sequence were staged by Greg McMurry and the VIFX effects crew. For the underwater blasts, pyro was rigged in the facility's six-foot-deep outdoor water tank and shot at 200 frames per second. Pyro effects, by Richard Helmer, were time consuming and required meticulous preparation. "Everything you do underwater takes forever," McMurry commented. "The most difficult thing about doing pyro underwater, of course, is that everything gets wet; so you have only a limited amount of time to get your shot once everything has been rigged. If you wait too long, nothing will happen when you set it off because the pyro will have been saturated with water."

Fifteen mines of varying sizes were built and submerged in the tank to simulate a minefield in forced perspective. "The largest mine, the one that was actually loaded with pyro, was about twelve inches in diameter. The smallest was about three inches. Inside each mine was the Riddler's signature question mark, which was electronically lit." The mines were built into a grid in the concrete block tank, then photographed through a four-foot glass port. "We could line up the whole minefield and get just the perspective we wanted so that it looked as if it was going off forever." On one take, in an attempt to create the ultimate underwater explosion, the effects crew overdid it and blew out the glass viewing port. "We were trying to push the envelope with bigger and bigger explosions – but we pushed too far. That was a bit of a set-back, but we got it back together within a day and were shooting again."

The ensuing batwing crash and sub sequence involved approximately ten shots filmed during a two-week period at the Los Angeles Swim Stadium, with inserts achieved at the VIFX water tank. At the Olympic-size pool, a sixth-scale batwing model built by Grant McCune was photographed high-speed – at 60 frames per second – by the VIFX team. For the approach and crash, the model was mounted on a track rig – driven by a system of belts and cables – which was positioned ten feet above the pool. The impact was filmed from an underwater vantage point. Once the batwing was submerged, it was switched to an underwater track rig for further movement. "Pete Romano was our underwater cameraman," McMurry related, "and he used his own HydroFlex camera housings for the work. Once the model was in the water, we rigged it so that the wings would jettison and it would become the bat-sub. Each one of the wings blew off separately, which we did with pyro effects."

Both the pool and tank were treated with green food coloring and milk to make the water cloudy and give it appropriate visual density. "The pool filter was really efficient," McMurry recalled. "It kept filtering out the food coloring and milk, so we were constantly having to add more to keep up with that." Bubbles were added through bubble wands positioned around the tanks to give the shots a greater sense of activity. The underwater sequence was also enhanced with searchlights, replicating those emanating from Claw Island in the live-action shots. "We used xenon searchlights which we had hanging from overhead. We had to time the light beams moving through the water just perfectly so that they would illuminate whatever action we wanted to capture on film. The lighting

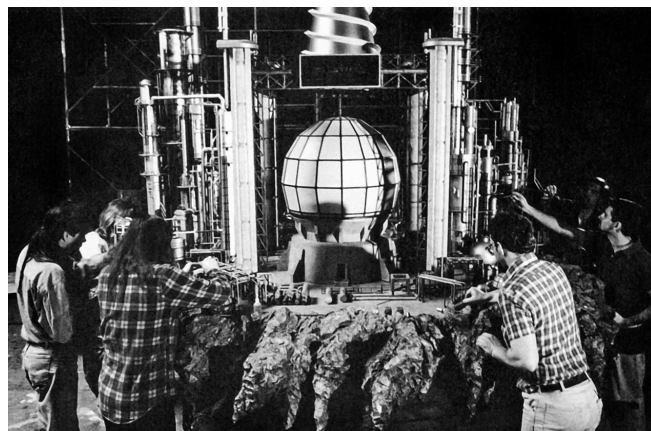
With his cape deployed like a parachute, Batman plummets six hundred feet in a breathtaking dive from the rooftop of a Gotham hotel. PDI accomplished the action digitally with a computer generated superhero and cape animated utilizing high-resolution motion capture data from a performing gymnast. The computer generated stuntman was then composited into free-fall background footage created digitally by WBIT.

scheme for the scene was such that the water was perfectly dark except when it was hit by a searchlight; so we had to have searchlights pass over the area we wanted to see at just the right moment for each event.” Insert shots – including closeups of the wings separating – were filmed at the smaller VIFX tank. Nearly all of the completed shots required digital wire removal since it was impossible to shoot the underwater footage without rigs and track showing up in frame.

To save Robin, who has been grappling underwater with some villainous assailants, *Batman* launches himself through one of the sub’s missile tubes. “We propelled a *Batman* puppet on wires for that shot,” McMurry explained. “The initial launch was done with compressed nitrogen. There was a tube of nitrogen gas inside the sub which was operated by remote control. As the sub came towards camera and got into the position we wanted, we would launch the puppet with a trail of bubbles streaming out from behind him. The trouble was that, unless something is shaped aerodynamically like a torpedo, anything you propel through water is going to veer off in all directions. So the puppet had to be mounted to a wire in order to make it travel in exactly the direction we wanted. That wire was then digitally removed.”

Swimming to the surface, *Batman* and Robin see Claw Island being lifted into the air by a massive hydraulic cylinder. “We didn’t physically move the model,” Boyd Shermis said. “We just put it on a twelve-foot cylinder and moved the camera to create the illusion that it was rising.”

Separated from his young protégé, *Batman* makes his way into the Riddler’s lair, where he finds both Robin and Chase imprisoned in cages poised over the hollow cylinder. The Riddler releases them, causing the two to fall into the cylinder toward certain death on the rocks and crashing surf below. *Batman* dives after them, catching both and securing them with cables. The shot, with another skydiving camera move, was created with the principal actors filmed bluescreen and composited into a CG background provided by Rhythm & Hues. “We had to composite the 2-D plates of the characters into a 3-D world, and supply scale and speed inside the cylinder,” explained Rhythm & Hues effects producer Teresa Cheng. “There was a lot of R&D for the look of the tunnel – which we modeled from blueprints supplied by the production – and much creative judgment as to textures, colors and lighting. The most important thing was the rate of speed for the fall; but since the scene was cut like a music video, we had to work on the apparent speed



Modelmakers add finishing touches to the ten-foot-tall Claw Island lair, setting for a climactic confrontation between Batman and his nemeses. The miniature set included welded steel columns representing an abandoned factory and a giant brain wave collector fashioned from a pyrex glass cone. Incoming energy waves captured by the collector would be realized through digitally enhanced laser effects designed and shot by Boyd Shermis and his team, then composited by CIS.



and scale, not the actual physics. The shot was an illusion, so it just had to look right.”

“It was an illusion of speed,” added Kathy White, effects supervisor on the sequence. “We were in a CG world, falling down this tunnel, so the camera speed and the tunnel length needed to be believable. But in real life, the acceleration rate is something like thirty-two feet per second per second, which would have had us hitting the ground in the first shot. So we did a cheat, with the walls and bottom as separate elements, each coming up at a different rate of speed relative to each other. The perilous sense of freefall was achieved by dropping our camera down the tunnel very fast. Continuity from shot to shot was maintained by allowing the bottom of the tunnel to move away from the camera at some percentage of the camera speed. We also used motion blur, textures and detailing to add realism to the shaft.” The cylinder’s steel surface, cut through with Riddler question marks emitting shafts of light, also helped Rhythm & Hues impart a dangerous sense of speed and scale, with lights and shadows interacting with the live-action characters pulled from bluescreen and integrated into the digital environment.

Batman saves the day and, with Two-Face having taken a seemingly fatal fall and the Riddler reduced to babbling incoherence in a padded cell at the Arkham Asylum – another Grant McCune miniature – Gotham City has once again been given a respite from crime. As the latest chapter in an ongoing series, *Batman Forever* achieved a stylistic look emblematic of comic book graphics. The classic production tools – motion control miniatures, matte paintings, bluescreen, huge soundstage sets, location work – had been needed to meet the creative demands of the production. The adroit use of computer generated performers, the construction of a completely synthetic cityscape, the digital layering of elements and image processing flourishes also helped bend the images into comic book compositions.

For John Dykstra, who had come of age during an era of physical materials and photochemical processes, the new digital tools would forever alter the creative dynamics of filmmaking. “Breakthroughs are sort of commonplace these days,” Dykstra reflected. “The sky’s the limit now. But this embarrassment of riches puts you in the position of having to embrace change constantly. When you set out to do a picture that will require a year to finish, you have to recognize that ideas you are unable to execute at the beginning, because of limitations in computer imaging technology, may well become practical by the end of the picture. So now you have to anticipate. Delving into what computers can do is sort of like opening Pandora’s Box. In fact, I don’t think anyone really knows what the limits of computers are, because right now there’s somebody someplace who’s working to overcome one of the currently accepted constraints.”

Joel Schumacher shared his effects supervisor’s appreciation of the new visual effects tools now available – particularly since those tools made it possible for him to complete his movie on a compacted schedule. “We were all scared at times because the production deadline seemed to be coming at us like a speeding train,” Schumacher admitted. “But we made it; and everybody who worked on the film deserves an enormous amount of credit – none more so than the visual effects department. Amazingly, we did not lose a single effects shot – not one planned shot was dropped

Engineered at Metro-Goldwyn-Mayer, the Chutes Design was given four dimensions by the digital team. The digital team, in turn, projected the Riddler’s question marks, which were projected to create a slight rippling effect. Lead technical director Tomás Rosenfeldt, technical supervisor Jerry Weil and supervising producer John Follmer survey the results.

from the movie because of deadline pressures. I can't think of an adjective big enough to describe what John Dykstra did in organizing that effort."

Batman Forever photographs courtesy of Warner Brothers. TMs and ©1995 by DC Comics. All rights reserved. Production still photography by Ralph Nelson. Miniature unit still photography by Virgil Mirano. Additional clips and photographs courtesy of Warner Brothers Imaging Technology, The Chandler Group, Composite Image Systems, Pacific Data Images, Illusion Arts, MetroLight Studios, TFX and Grant McCune Design. Special thanks to Jeff Walker and Jess Garcia.

EFFECTS SCENE

THE LAST HURRAH

article by Nary C. Mason

When Mark Stetson and Robert Spurlock wrapped work on *Waterworld*, their final project before permanently dismantling Stetson Visual Services, the scene was distinctly celebratory. “It was like an Irish wake,” recalled Stetson, who with Spurlock founded in 1989 what has been considered the industry’s premiere miniature effects firm. “Nearly every crew chief who had ever worked for us was involved in that show – George Trimmer, Ian Hunter, Henry Gonzales, Dana Yuricich, John Stirber, Scotty Schneider, Richard Stutsman, Ron Gress – so it turned out to be a wonderful last hurrah.’ We even had sweatshirts made that were emblazoned with that slogan.”

The partners’ decision to dissolve the six-year-old company was in no way born of necessity. “I would hate to think that our actions were misconstrued as evidence of a decline in business or in the viability of miniature effects,” remarked Stetson. “We’ve worked on sixty-eight features and more than a hundred commercials since we started; and right to the end, business has flourished and the projects coming in have increased in complexity and scope. In all that time, I don’t think we’ve ever had a slow period that lasted any longer than four weeks. So I have no doubts – had we been inclined to continue – that we could have been very successful at this for a long time.”

Neither partner, however, had such inclinations. “Closing was a conscious, deliberate decision – a plan we followed from the start,” said Stetson. “Our intention was to do this for a five-year period; and we achieved that goal. We’re very proud of what we’ve accomplished. It’s been a great period in our lives – very intense, very rewarding, very satisfying – but both of us felt that this was a good time for a life change, a chance to grow in new directions, to trade in all the headaches for a whole new set.”

Stetson and Spurlock first met in 1979 while working for Douglas Trumbull on *Star Trek – The Motion Picture* – Stetson as a modelmaker and Spurlock in the physical effects department. Having originally pursued a career in industrial design, Stetson had worked as a modelmaker trainee for General Electric in Connecticut before coming to California to study product design. All that changed the night he attended the opening of *Star Wars* at Mann’s Chinese Theater. “I’ll never forget the moment I saw the first little scout ship go by, followed by the giant cruiser. I thought, ‘Nice models!’ Then I realized, ‘Hey, I can do that!’” Spurlock, too, had landed on the West Coast after a career-defining epiphany. Armed with a degree in mechanical engineering, he was designing irrigation equipment for a company in Colorado Springs when he happened upon a copy of *The Making of Jaws*. “I read it and was so fascinated by the work done in that film that I literally just picked up and moved out here in the summer of 1975. I started working in the industry building sets, and eventually got into miniature work on *King Kong*.”

Following their shared experience on *Star Trek*, the two went their separate ways, working together on and off in the ensuing years. In 1988, they connected again at Boss Film Studios where they collaborated on several big projects. “Bob sensed that I was getting restless and ready to venture out on my own after nine years at Boss,” recalled Stetson, “so he got a copy of ‘Combat Rock’ by *The Clash*, and blasted the lyrics ‘Should I stay or should I go’ through the shop a few times. Soon the answer became clear.”

On January 1, 1989, Stetson Visual Services was launched, with its two partners quickly establishing a niche for themselves in miniature effects work. It was a banner year. Beginning with *The Abyss*, the fledgling entrepreneurs contributed to five of the seven films considered for an Academy Award in visual effects that year, and received a Saturn Award nomination for their elaborate work on *Total Recall*.

Over the years, there has been no shortage of challenging projects to showcase the talented duo – from miniatures of the foreboding mansion and peaceful village setting in *Edward Scissorhands* to the abandoned zoo park and Penguin hideout in *Batman Returns*; from the vertiginous New York cityscape in *The Hudsucker Proxy* to an elaborate miniature oil rig platform for *On Deadly Ground*. A host of other credits include such notable features as *Back to the Future – Part 3*, *Dick Tracy*, *Barton Fink*, *Toys*, *The Santa Clause* and *Interview With the Vampire*. For *The Shadow*, Universal purchased and resurrected the miniature cityscape that SVS had previously built for *Hudsucker Proxy*. Stetson and a crew of twenty modelmakers redressed the skyscrapers, adding rooftops – which had not been needed for *Hudsucker*’s up-angle shots – and a fine level of detailing to create the stylized 1930s backdrop so memorably featured in the film.

One of the largest miniatures ever constructed by the modelmakers was a replica of the Florida Keys’ Seven Mile Bridge for a climactic sequence in *True Lies* in which a bridge is exploded as terrorists race across it in a truck. “We had just seven weeks to build a five-span miniature,” Spurlock recalled. “At one-fifth scale, it was enormous – measuring nearly two hundred feet, with eighty feet of it consisting of a fully detailed rendering and the rest of it just scaffolding to support the track needed to get the model truck up to speed. Then we had to haul it in pieces to Sugarloaf Key and set it up just offshore in deep water. As if all that weren’t complicated enough, we were



Company partners Robert Spurlock and Mark Stetson bid farewell to the now-vacant building which – as Stetson Visual Services – had been a mecca of modelmaking for six fruitful years.



Waterworld – with its enormous replica of the Exxon Valdez – was the last of sixty-eight feature film assignments for Stetson Visual Services.

working on *The Shadow* at the same time; so Mark was busy directing shots for that film in L.A. while I was down in Florida wrangling the bridge.”

While the True Lies assignment stands out as one of the bigger projects tackled by the company, every feature film and every commercial that went through the shop presented its own unique challenges. “In retrospect,” Stetson observed, “it’s hard to single out any one effort. With every project there’s a sense of starting from scratch – new people, new client structure, new corporate hierarchy. That’s the nature of the film business. It’s a lot of work; but, ultimately, that’s what gives you a sense of satisfaction and pride.”

Fittingly, the company’s final endeavor – the futuristic adventure epic *Waterworld* – may well qualify as its most ambitious. “We really went out with a bang on that one,” said Stetson. “I think the mechanical effects we did for *Waterworld* were more complicated than anything we ever attempted before.” The SVS crew was tasked with building an elaborate underwater city as a background element, and also created a 110-foot-long model of the Exxon Valdez. “I think that was the largest single object we’ve ever made,” noted Spurlock. “We built it in the shop, then had to ship it to the Mojave Desert where it was assembled and filmed. The ship blows up and sinks; so we constructed breakaway parts designed to split the model in half, and simulated its sinking by using a 100-ton crane to hoist up one end. Then we split off the tail cap and sank that separately in a pool.”

Having concluded the *Waterworld* assignment, dispersed their crew and sold the company’s assets, both Spurlock and Stetson are preparing for new chapters in their respective careers. Spurlock, who has purchased a home in Oregon and moved there with his family, is first enjoying a much deserved sabbatical. Stetson, having set aside the burdens of running a business in favor of more creative pursuits, was recently hired by Digital Domain as a staff visual effects supervisor. Whatever divergent directions their lives may take, the two men intend to stay in touch. “We were fortunate in that we had a unique balance in our partnership that served the business well,” stated Spurlock. “We complemented each other. It was like a good marriage.”

Stetson concurred. “That’s the one sad thing about closing. We’ll miss each other and we’ll miss our crew. Other than that, we’re a couple of the happiest people in Hollywood.”

COMMERCIAL SPOT THIS FROG'S FOR YOU

article by Estelle Shay

Bug-eyed, squat and lovable, the amphibian stars of a humorous ad campaign for Budweiser have television viewers clamoring for more. In the first of two thirty-second commercials created for Anheuser-Busch, three frogs are seen sitting in a swamp at night. One begins croaking the word 'bud,' the second pitches in with 'wise,' and the third completes the chorus with a long, drawn-out 'er.' As the frogs repeat their singular chant, the camera pulls back to reveal a shack with its neon Budweiser sign reflecting in the water.

Conceived by ad agency DMB&B of St. Louis, and directed by Gore Verbinski of Palomar Pictures the award-winning spot was realized with the aid of animatronic frogs – affectionately known as Bud, Wise and Er – built by Stan Winston Studio. “It was a great concept – simple and funny,” commented Winston visual effects supervisor John Rosengrant. “But for the comedy to work well, Gore needed the frogs to come off as real. That was our main parameter.” Another was to differentiate the frogs by size. “We were originally going to build them close to the size of real bullfrogs, until we started doing research and found that even the largest of them don’t get that big; so we had to scale them up somewhat. Wise – the smallest of the three – ended up being about the size of a big American bullfrog.” To further distinguish the frogs, Rosengrant and his crew assigned individual personality traits to each. “Bud was a big, beer-drinking couch potato, Wise was a wiry wise-guy and Er was the flashy one.”

Following approval of the designs, the frogs were sculpted by Rosengrant, Chris Swift and Scott Stoddard, with assistance from Ken Brilliant and Mark Maitre. Skins were cast from silicone molds by Tom McLaughlin. “We chose silicone rather than foam latex for its translucency,” noted Rosengrant. “Also, the frogs would be sitting in water, and we were afraid that putting foam latex in water would be a problem.” Rosengrant, Mark Jurinko and Jason Matthews painted the skins to match selected reference photos. “Bud was fairly simple – mostly light green with brown mottling; Wise was louder, with a colorful pattern that included bright yellows intermixed with green; and Er – the flashy one – had blotchy mottling and stripes that ran counter to his body.” Mineral oil was used to coat the completed skins, providing a realistic slimy finish. Overseeing the puppet mechanics were Rich Haugen and Al Sousa. “Gore wanted us to build into the animatronics everything that a real frog does,” Rosengrant noted. “He wasn’t too worried about leg movement because the frogs don’t actually go anywhere; but he did want to see their throats ballooning and body breathing and eye movement.” Frog armatures were built for each character, complete with properly jointed legs. Rods inserted in the torsos provided body articulation from below. Eyes were hand-painted to match real frog eyes, with radio controlled, tiny watch-like mechanisms to effect movement and eyelid blinks. Puppeteers controlled jaw motion through the use of telemetry devices worn over their own jaws. And throat ballooning was accomplished by pumping air into custom-made bladders inside each puppet.

Following nine weeks of preproduction, the frogs were pressed into action during a three-day shoot at Universal Studios where the production company constructed an elaborate set, complete with cypress trees and shack, then flooded a portion of the stage in two feet of water. Puppeteers – one for each frog – were positioned under the set to control body movements and bladder inflation, while others above operated the telemetry devices and radio controlled eye movements.

The commercial – which aired initially on Super Bowl Sunday – was an instant hit and went on to earn a Clio award, prompting Anheuser-Busch to commission a second spot. For the sequel, ad agency DDB Needham and director Simon West of Satellite Films took the concept a step further. In the new scenario, the frogs are seen sitting on a log in a swamp. A Budweiser delivery truck zipping down the highway captures their attention. The biggest of the three licks his lips in anticipation and, as the truck hurtles by, shoots out a sticky tongue. Latching onto the back of the vehicle, the tongue stretches impossibly, finally whipping the frog off his feet as his buddies watch wide-eyed. A final shot reveals the frog sailing through the air behind the truck, ‘yee-hahing’ in delight.

With only three weeks allotted for preproduction, West called upon Rick Lazzarini’s Character Shop for puppet effects and Digital Domain for computer enhancement. Though ostensibly the same characters, all new puppets were required. “Simon wanted to reduce the size discrepancies between the three frogs,” noted Lazzarini, “as well as punch up the characters a bit to make them appear friendlier.” From sculptures created by Eric Schaper and Bill Zahn, two-part molds were made and foam latex skins cast. “Stan Winston gave us the skins from the originals to help match the coloration,” said Lazzarini, “and Eric Schaper did a brilliant job painting them to look just as translucent and slimy and realistic as any silicone. Then we applied a final coating of K-Y jelly.”

To give the frogs a broad range of expression, mechanics Evan Brainerd, Jonathan Spence and Tony Rupprecht employed a combination of radio control and rod puppetry. Loose-jointed leg armatures were utilized for passive movements of the limbs, while bodies were controlled by rods. For a shot of one of the puppets planting his feet, special rods were installed. “We made little cuts in the log, with holes just big enough to allow the puppeteer to lift the feet and set them down again,” Lazzarini elaborated. Other articulation included eye blinks, side-to-side eye movement, mouth



Artist Mark Jurinko of Stan Winston Studio paints one of three animatronic frogs created by the company for a Budweiser beer commercial.



Frogs for a follow-up commercial were made by Rick Lazzarini of The Character Shop.

movement and breathing, and a throat ballooning effect which used a finely tuned air delivery system in place of manual inflation, operated via radio control.

Special consideration was given to creating as much animation in the hero frog as time and budget would allow. “We packed six servos inside his body and one or two motors outside that ran a rhythmic breathing mechanism,” Lazzarini explained. “Plus, we added additional expression by incorporating smile and smirk mechanisms in his lip.” A special purpose jumper puppet was built to supplement the hero frog. “Our hero version had so many servos and cables coming out of him that something simpler was needed for shots of him being pulled off the log. So we built a simpler version which had just breathing, mouth movements and eye blinks. Then we ran our power cord down the tongue and out through the mouth, since Digital Domain was going to be superimposing a digital tongue over it.”

For live-action filming on location in New Orleans – where an authentic bayou served as the backdrop – Lazzarini and his crew hit the ground running. “There was barely time for the paint to dry on the puppets, and virtually no time to rehearse,” Lazzarini recalled. Six to eight puppeteers were required to operate the characters – some working off-camera above ground, and others beneath a raised platform set built in the swamp. Final shots of the airborne frog were filmed against a bluescreen, with puppeteers manipulating each limb via rod control to mimic the motion of flying.

At Digital Domain the frog was composited onto a plate of the live-action truck, and a digital tongue added. “The CGI tongue went through many iterations,” related Digital Domain executive producer Ed Ulbrich. “Since we were going for reality, we examined lots of documentary stock footage – but reality proved very unappealing. A real frog’s tongue is pretty grotesque – something we felt certain the brewery wouldn’t want associated with their product. So we ended up taking a certain amount of artistic license to make the tongue cuter and friendlier, with more elasticity and stretch and a lot less ooze and goo.” Under the direction of computer graphics supervisor Randall Rosa, digital artists used Alias and Softimage to render and animate the tongue. “Then we used our own proprietary motion tracking software to track it to the moving frog and truck in the live-action plates. It was a tricky process, because each time we made changes in the way the tongue looked – rendering or shading it to make it less grotesque – the geometry would change and we’d have to go back in and retrack it.”

With response to the second commercial every bit as enthusiastic as the first, chances are good that audiences will be seeing more of the Budweisers frogs.

COMMERCIAL SPOT BATTERIES INCLUDED

article by Estelle Shay

Look out Energizer Bunny, here come the Puttermans. Star performers in an ongoing series of Duracell commercials the Puttermans – mom, dad and two teenage children – are not just your ordinary suburban family. Like articulated dolls, but life-size, with giant batteries planted squarely in the middle of their backs, they look and move remarkably like animatronic, stop-motion or even computer generated characters. But they are none of those. In a medium where effects often serve to simulate reality, the Puttermans are just the opposite – real people masquerading as artificial.

The commercials, produced by the Ogilvy & Mather ad agency, feature a series of vignettes in which members of the Putterman family comment wryly on the virtues of the Duracell whenever unfortunate friends or relatives – running on inferior batteries – end up face down in a plate of tetrazzini or crashing into a museum display. Creating makeups for the actors portraying these characters was Emmy-winning Steve Johnson, whose company, XFX, has produced groundbreaking imagery for feature films, television, commercials and theme parks. Approached by Ogilvy & Mather early in the project's conceptual phase, Johnson was given scripts and tasked with devising characters that would throw audiences completely off balance. "They wanted something that could go up against the Energizer Bunny," said Johnson, "something that people would look at and not be able to figure out how it was done, where there would be very little frame of reference. So we thought of doing life-size toys, using real people as prosthetics."

For a number of months prior to the start of the project, Johnson experimented with various makeup approaches and designs. "We had to find exactly the right balance between prosthetics, wardrobe and reality in order to keep audiences guessing. The difficulty was determining just how far to take it. We decided that in order for the effect to work it had to be incredibly clean and seamless and all-inclusive. The characters had to be false cartoon people from their shoes all the way to the tips of their fingers and the tops of their heads. So we designed makeup and costumes that would literally cover every inch of exposed skin with rubber." Also guiding the designs was input from the agency based on intensive test marketing. "They were intent on creating ground rules for the characters that would last for ten or fifteen years. So they test-marketed everything down to how the part on the side of a guy's hair would affect housewives in the midwest. It was that specific."

With director Barry Sonnenfeld on a tight schedule due to other commitments, Johnson and his team had only eight weeks to complete the makeups for the initial four commercials. “Bill Corso and Greg Smith did quite a bit of the initial design work on the look of the characters,” said Johnson. “The faces – over-the-head appliances sculpted in foam rubber – were really the trickiest aspect of the project because it was difficult to find just the right balance. We needed to allow the distinct personalities of each actor to come through the masks, but we didn’t want the makeups so subtle that the actors ended up looking like people dipped in rubber.” At least three versions, plus variations of each, were explored before a median point was found that conveyed just the right combination of cartoon character and realism. “Around the mouths, for instance, we tried to keep the prosthetics fairly thin so that expressions could be seen. But depending on the character, we would go a bit broader in other areas like the forehead, the ears and the jaws.” A lower lip piece was applied separately to allow for shrinkage of the foam rubber. “With the lower lip pieces, it was easier to blend around the mouth; and since the lower lip is often a problem area, we could do repairs without having to remove the entire mask.”

Airbrushing, rather than hand painting, was used to color the prosthetics. “We used soft blended colors and applied them intensely so that they would read a bit false, but not too much. Then we applied a bit of K-Y jelly so that the prosthetic – which was sculpted smoothly to reflect a lot of light – would reflect even more, giving it a slight plastic sheen.” A final touch to the makeup was the addition of intensely white dentures to further emphasize the cartoon nature of the characters, and separate foam rubber hair appliances designed and sculptured by Moto Hata. “That was a highly labor-intensive process because it involved sculpting individual strands. Also, the agency was very, very specific on the hair, using their demographic studies to help determine exactly the right styles. We ended up doing several hair sculptures for each character before agreeing on a specific design – it was very much a back-and-forth exchange between the agency and us.”

Equally as eye-catching as the sculpted faces and hair were the brightly colored, plastic-looking costumes created by Bill Bryan and Lynette Johnson. While consideration was given to sculpting the clothes in clay, then molding and casting them in rubber, a different approach was ultimately used.



For a series of commercials for Duracell batteries, Steve Johnson and XFX were called upon to create suits and prosthetic makeups to make actors look like a family of giant dolls.



XFX makeup artist Greg Funk applies finishing touches to one of the characters.

“We decided we’d have more freedom if we simply fabricated the costumes,” Johnson observed, “so we got a stylist to work with us on designs. We patterned the outfits like normal clothes, except that instead of using fabric, we cut the patterns from sheet foam rubber. Then we went back in and created wrinkles, sculpturing them the way the material would fall naturally.”

One unusual design aspect incorporated into the outfits was socketed shoulders. “It was kind of a subtle thing, but it really forced the actors to move in a doll-like manner because the shoulders only slid in one direction.” Once the clothes were completed, the artists added color by painting the foam rubber in a very cartoon-like fashion, using bright colors and highlights and shadows. The trademark battery packs, visible from the rear of each character, were patterned after real batteries – sculpted then vacuformed, with the ‘Duracell’ labels sent out to be custom painted at a motorcycle shop. A final step was the application of a coat of ultra-shiny urethane to effect a candy-gloss, laminated look to the entire surface of the costumes. “That was a nightmare because the urethane had to set up in just the right amount of time or we would get either drips or overlap lines. We tested for weeks, but no substance on this planet was doing quite what we needed it to do. So Lennie MacDonald – who really saved the day – researched the spec sheets on an existing urethane and determined exactly what had to be changed. Then he went to Terry McGinnis at BJB Enterprises and got him to customize their catalyst formula to meet our specific needs. It worked fine.”

To heighten even further the 3-D cartoon look of the actors, areas of exposed skin, such as arms and hands, were covered with prosthetics. “For the men,” Johnson elaborated, “we designed slightly bulky, tight-fitting foam rubber gloves with the detail downplayed so that their hands would look very smooth and toy-like. For the women, since we didn’t want to bulk them up, we made custom tailored tight spandex gloves and painted fingernails right on top of them.”

With every square inch of their bodies encased in varying thicknesses of foam, the actors faced a considerable challenge in bringing the characters to life during the shoot, “One of our main concerns was whether or not it would work to have really bizarre cartoon people living in a real environment. So Barry elected to downplay the robotic aspects by directing the actors to move as naturally as possible, allowing the restrictions of the costumes to inhibit their movements. That approach made them look less false and worked well with the fact that their faces were fairly mobile.”

With six commercials completed to date and several currently airing on network television, the Puttermans – with their delightfully bizarre look and their wicked sense of humor – are attracting plenty of attention. “Doing a project like this is one of the perks in this business,” Johnson reflected. “It’s easy to do an effect meant to get a reaction of revulsion or horror; but creating something that’s humorous is a lot more challenging. In designing these characters, we had to delve into the psychology of what makes something funny – and that’s a lot of fun.”

VIDEO BEAT

SOLDIERS OF FORTUNE

article by Nark Sawicki

A flurry of martial images and the thunder of marching boots set the pulse of the scene. There is a flash of chrome, a familiar form, and at last we see Michael Jackson leading a vast army of crack troops into a cheering city. With a silent signal from the unlikely general, the camera pulls back far into the sky, revealing millions of infantrymen joining Jackson in performing a perfect staccato lock-step. The scene is part of the music video, *History*, a dramatic fantasy that combines the ambiance of a totalitarian world with the superstar persona of Michael Jackson.

Of the many tasks confronting visual effects supervisor Alan Munro, the two “*Triumph of the Will*” shots of Jackson surrounded by millions were among the most challenging. Since box lunches alone for such an enormous number of performers would have bankrupted any production, Munro called on Illusion Arts to create the throngs of synthetic soldiers. Bill Taylor and Syd Dutton, co-owners of the company, subsequently posed the problem to their digital supervisor, Richard Patterson. Recipient of a 1994 technical achievement award from the Academy of Motion Picture Arts and Sciences, Patterson had been instrumental in assembling the computer department for Illusion Arts and had created impressive digital shots for *Beverly Hills Cop 3*, *The Shadow* and, most notably, *Fatherland*, for which matte artist Robert Stromberg created digital paintings of a 1960s Berlin with Hitler still in charge.

The first shot of Jackson leading a long parade of soldiers was realized through straightforward, traditional techniques. A live-action motion control system supplied by Image G was employed by Bill Taylor to photograph Jackson and three hundred marchers on location in Budapest. “At the time of shooting,” said Taylor, “the military emergency in that region prevented us from using the regular army. So we assembled a crew composed of British paratroopers, police cadets and ballet dancers for the shoot. Despite their disparate backgrounds and uncomfortable costumes, our soldiers performed flawlessly.” The soldiers were filmed marching toward camera as it tilted and zoomed. To provide the next section of marchers, the same regiment was moved further back and shot marching from where the rear line of the first group ended. A third element was generated the same way by moving the complement of troops back further still and repeating the motion control tilt. Taylor overlapped the marches slightly to allow the use of soft splits between the groups.

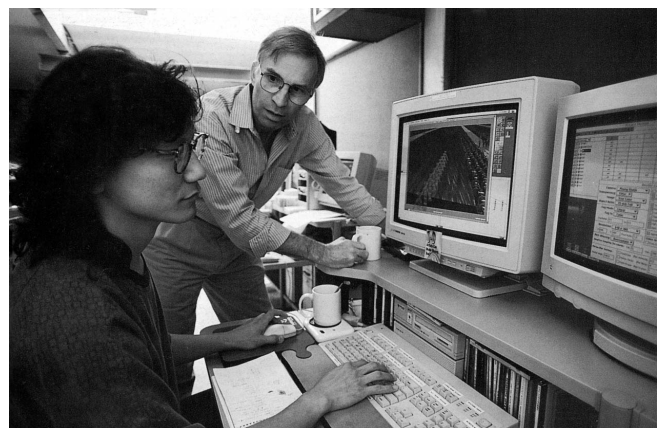
All of the film elements were scanned into the computer where they would be composited with a painted background of an enormous city square. "The two principal challenges in the shot of the soldiers marching behind Michael were matching the zoom and tilt on the painted background and blending the three groups of soldiers together," Patterson commented. "The motion control rig locked the groups of soldiers together, but it did not provide all the data necessary to exactly replicate the move on the painting. So we had to track the shot in the computer using After Effects software. The process was complicated by the fact that the image detail available for tracking tended to be near the edges of the frame where there was the maximum distortion. A piece moving through the outer portions of the image during a tilt or zoom will change at a different rate than detail in the middle of the image. Numerous passes were required before key-frame parameters were found that allowed the move on the painting to match the live-action zoom and tilt."

Robert Stromberg painted the background for the shot, depicting not only the square but also the most distant rows of soldiers to fill in and extend the three motion control elements. "I find that it's very useful to block in these paintings with oil and brush to start with," stated Stromberg. "You can change things very quickly and obtain wonderful romance through the natural accidentals inherent in the process. After I had refined the paintings to a certain point, I had them scanned into Photoshop where the final subtle accents were added digitally. While I was in Prague for *Fatherland*, I took a great deal of photographic reference of buildings. The textures of those facades were used to enhance the realism of the History paintings."

The second shot – a tremendous pullback from Jackson that reveals what appears to be millions of performers – was laid out by Alan Munro. The live-action plate began with a closeup of the star and then zoomed back as wide as was physically possible. In the computer, an additional move would be created to link up with the zoom and pull back even farther on the original scene to create a bird's-eye view. The generated move data would be used to provide synthetic camera moves on computer generated soldiers, as well as on a background matte painting done by Stromberg. "It was very difficult to work out a design for this matte painting," said Syd Dutton, "which included millions of soldiers in formation in an impossibly large square. Because of the frenzy of shooting, preplanning was thrown



Illusion Arts owners Bill Taylor and Syd Dutton discuss a matte painting for the Michael Jackson History video with artist Robert Stromberg.



Fumi Mashimo and digital supervisor Richard Patterson insert cloned marchers into a shot.

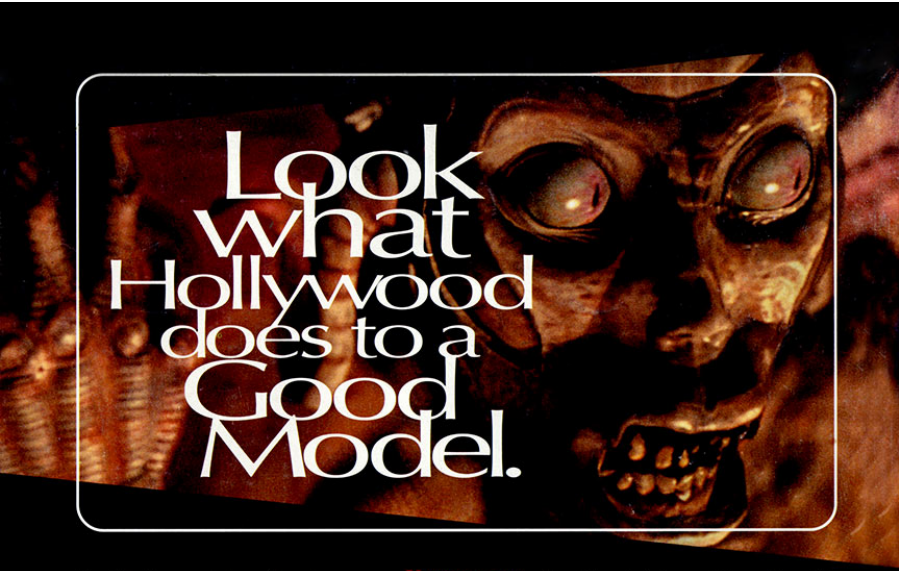
out the window. The basic plate was filmed at the end of the day, with an unfortunate shadow on the 'troops.' Alan, Rob and I started throwing ideas back and forth with sketches. We came up with an arch that would be included in the painting to justify the shadow on the plate photography. The troops were segmented into regiments for quicker readability, and pillars were added to provide visual interest and as a perspective device to focus the viewer. After the initial design phase, Rob and I started a traditional painting and did some rough tests on motion control to check the distorted perspective. Rob then transferred the painting into the computer for the 'bones' of his digital painting. As usual, he did a brilliant job." Because a generator failure on location had resulted in the live-action plate being shot wild – without benefit of motion control – the zoom was tracked frame-by-frame in the computer.

Illusion Arts also relied on digital techniques to create large numbers of synthetic soldiers when it was determined that standard cloning techniques – such as shooting the same group of live-action soldiers in various positions and combining those elements – would result in unacceptable image distortion. Resident CGI expert Fumi Mashimo was volunteered to the task of digitally rendering one hundred dancing soldiers for a test. Using Electric Image software, Mashimo completed the assignment in two days. With Munro's approval he then began creating and rendering the soldiers that would be used in the video.

The decision was made to render two thousand soldiers at a time at 2K resolution, with each group positioned to satisfy the compositional requirements of the shot. "We rendered about twenty-five batches of two thousand puppets," said Mashimo. "We wound up with anywhere from fifty thousand to one hundred thousand individuals." Average rendering time was approximately fifteen minutes per frame. "The uniform of the soldier was painted in Photoshop and texture-mapped over the computer model. For the face, we used a photograph of Robert Stromberg – so what you see, in actuality, are thousands of dancing matte painters."

Though rendered out in Electric Image, the dancing soldiers were composited in After Effects. "Compositing synthetic soldiers behind the live-action soldiers required extracting a matte for at least the heads of the outside row of live-action soldiers," Patterson explained. "In this instance, we had brown uniforms against a brownish pavement, but we were able to manipulate the color channels enough to create a matte that could be used in conjunction with a garbage matte and a lot of frame-by-frame rotoscoping." Last-minute touch-ups to the shots, such as color correction and zoom speed modification, were made by CIS-Hollywood on their Flame workstation. Banners were also added to gently mask a few digital soldiers that looked slightly cruder than their side-by-side live-action counterparts.

The fruits of Illusion Arts' labor could be seen when Michael Jackson's History was released in May. The vista of thousands of dancing soldiers was a striking part of the video, even if the exact meaning of the shots remained unclear. "No one that I spoke to had any clue of what the meaning of the images was or what dramatic or aesthetic justification there was for the shots," Patterson commented. "From our standpoint, the motivation for the effort was primarily the desire to do something cool – and that required pushing both the hardware and the software beyond the limits of what they were designed to do."



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